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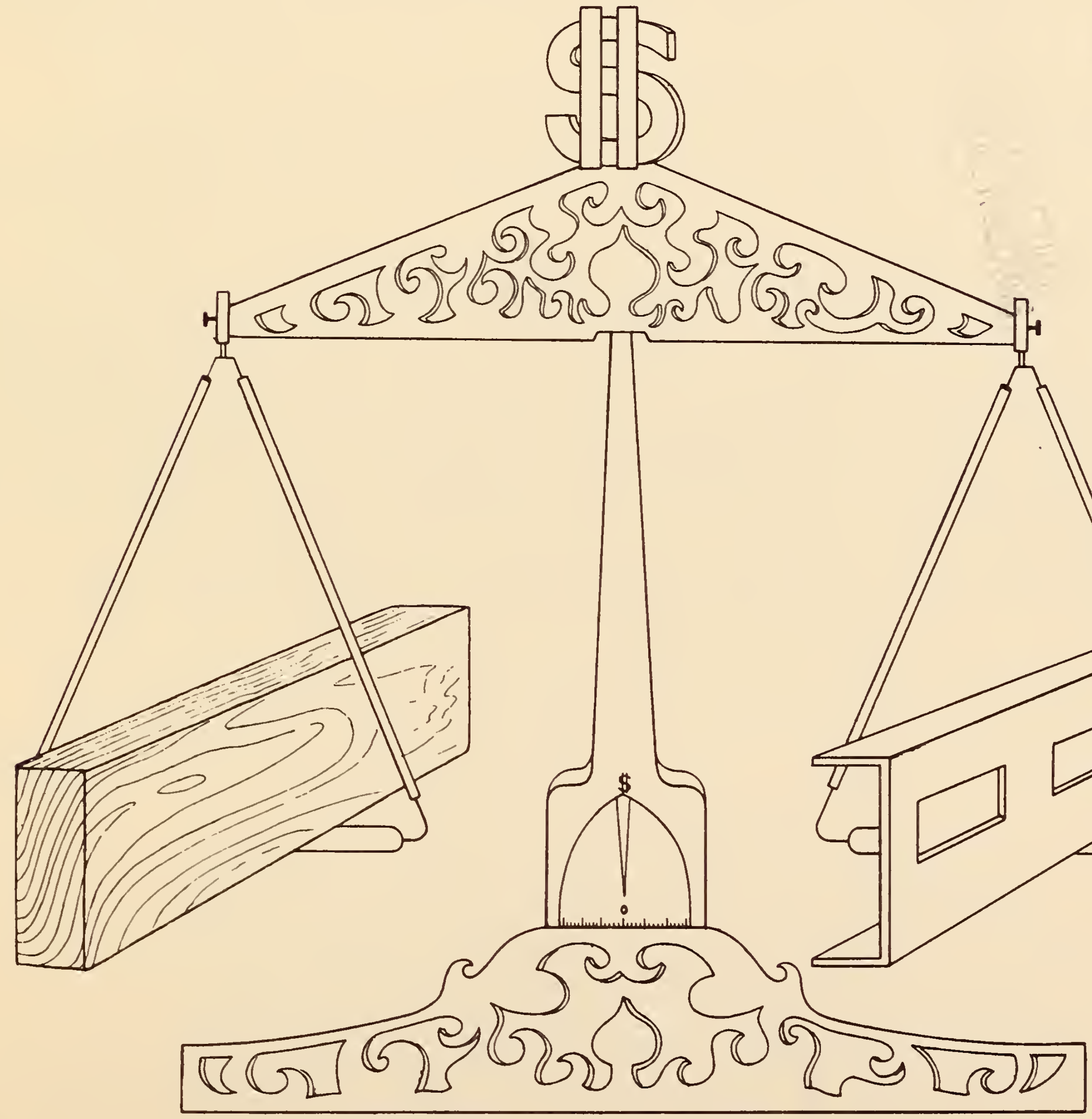
Comparative In-place Cost Between Wood and Steel Residential Floor and Wall Framing

by

Gerald A. Koenigshof



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PREFACE

Structural framing for residential construction is a major use of lumber in the United States. In appraising the outlook for demand for structural framing material, it is of interest to know how changes in materials and labor prices affect in-place costs of wood and steel framing.

This study analyzes in-place framing costs of construction systems using wood and steel based on price relationships for lumber, plywood, steel, and labor in 1970 and in the fall of 1972. Chicago, Los Angeles, and Washington, D. C. were selected as study areas. These cities and their surrounding metropolitan areas are the most active residential building areas in the United States.

By 1972 the prices of lumber and plywood had increased substantially. Costs of wood and steel framing at these higher prices were compared to determine the relative cost advantages of the materials.

Data used in developing in-place cost estimates were obtained from universities and private and government research organizations. Data from a comprehensive collection of field studies on in-place costs were analyzed in developing the tabular data shown in this report. These are an excellent source of information on quantities of materials and labor required on a unit basis for constructing floors, exterior walls,and interior partitions. Typical quantities of labor and material used for different types of construction and representative averages are presented.

A list of references is presented at the end of this report. These provided the basic data on which this study is based.

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This study showed that at 1970 prices for materials and labor, in-place costs of wood-framed floors and exterior walls were substantially less than for steel framing; for interior partitions, slightly less. At the high prices for lumber and plywood in the fall of 1972, steel became competitive with wood framing for large volume builders. For small volume builders, however, in-place costs slightly favored wood. A shift from wood to steel for interior partitions can be expected if prices of lumber and plywood remain at 1972 levels and no new wood partition framing systems are developed to compete with steel.

Keywoods: Residential building cost, homebuilding cost, steel house framing, floor framing cost, wall framing cost.

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HIGHLIGHTS

Cost of Floor Systems at 1970 Prices

At 1970 prices, installed costs of floors framed with wood joists are less than those for floors with steel joists if both are sheathed with plywood of appropriate thickness. For example, costs to a Los Angeles [1] builder purchasing in large volume [2] directly from steel, lumber, and plywood mills were estimated to be 30 to 40 percent more for floors with steel joists than for wood-framed floors. If the materials are purchased through retail outlets in large quantities, the steel-framed floors would be 40 to 50 percent more expensive.

Typical in-place floor costs [3] in dollars per square foot for a large volume builder in Los Angeles were estimated as follows:

	Wood joist floor	Steel joist floor
Material purchased direct from mill	0.462 to 0.495	0.587 to 0.673
Material purchased from retail outlets	0.478 to 0.510	0.563 to 0.758

Wood joist framing is less than half the total in-place floor cost, and it would have to be 75 to 129 percent more expensive than in 1970 (if prices for labor, steel, and plywood were to remain constant) for the total in-place cost of a wood-framed floor to be equal to that of a steel-framed floor.

For steel joists to be used extensively in the floor framing market, it would be necessary to establish a network of retail outlets for steel joists. Steel joists are now usually sold directly to large builders who are able to purchase in minimum quantities of not less than 40,000 pounds per order.

Steel joists must be precut at rolling mills to exact lengths specified by the builder. This practice avoids the markup by distribution centers, and the precutting eliminates for the most part, the scrap and waste at the job site. Usually, 4 to 6 weeks are required for delivery after placement of the order.

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[1] Los Angeles was used as an example because in-place cost there was between in-place costs at Chicago and Washington, D. C.

[2] Large volume is 40,000 pounds or more of steel and carload quantities of lumber or plywood.

[3] See tables 7, 8, 9, 14, 15, and 16 for costs by type of floor, builder, material, and labor for Chicago, Los Angeles, and Washington, D. C. These cities were selected as the most active residential building areas in the United States.

About two-thirds of the single-family homes are constructed by builders who build 25 or fewer homes per year. The wood versus steel joists cost differential for this group of builders would be even greater than indicated above.

Wood floor joists are traditionally spaced 16 inches apart. Engineered steel systems commonly have a 24-inch spacing with the larger span compensated for by thicker flooring. Forty-eight-inch spacing with still thicker flooring has been occasionally used.

Floor systems with wider spacing of joists require less material for framing whether wood or steel joists are used. However, this gain must be weighed against the higher cost of the plywood needed for wider joist spacings. For example, the 1 1/8-inch plywood required when joists are 48 inches apart costs 1.81 times as much as the 5/8-inch plywood typically used with 16-inch joist spacing. Of the floor systems examined, the one with 2x10 joists spaced 24 inches apart and covered with 3/4-inch plywood had the lowest cost.

Cost of Floor Systems at 1972 Prices

Rises in costs of lumber and plywood in 1972 compared with modest increases in costs of steel and labor made in-place costs for steel-framed floors competitive with in-place costs of wood-framed floors for large volume builders. However, for small volume builders, the in-place cost advantage favored wood floors by about $0.10 per square foot.

Cost of Interior Partitions at 1970 Prices

At 1970 prices, interior nonload bearing partitions using steel studs cost less to install than partitions using wood studs. For example, for the Los Angeles builder purchasing in large quantities, the costs of framing interior walls were about 10 percent less using 26-gage nominal 2x3 steel studs instead of 2x3 wood studs.

Framing for steel stud walls costs about $0.98 per linear foot for labor and materials, and for wood stud walls it costs about $1.10 per linear foot. Steel studs of 26 gage do not have the equivalent strength of 2x3 wood studs and do not meet current minimum property standards of the Federal Housing Administration. However, interior walls framed with steel studs with strength adequate to meet these standards are also estimated to cost less than walls framed with 2x3 wood studs spaced 24 inches on center. Much of the cost saving in steel is attributable to faster methods of installation that reduce labor costs.

Cost of Interior Partitions at 1972 Prices

In-place cost for interior partitions framed with steel favored the use of steel in 1972. Steel-framed partitions cost about $0.58 less per linear foot than wood-framed partitions for small volume builders and about $0.62 less per linear foot for large volume builders.

Cost of Exterior Walls at 1970 Prices

The comparison is reversed for exterior walls. Exterior load-bearing walls framed with steel studs cost about 20 to 25 percent more than walls framed with wood studs. Costs for exterior walls framed with wood studs range between $1.27 and $1.88 per linear foot; costs with steel studs range between $1.59 and $2.22 per linear foot. At 1970 prices it would require a 30 to 35 percent increase in the cost of wood studs to raise wood framing in-place costs to the level for steel-framed exterior walls.

Cost of Exterior Walls at 1972 Prices

The price of lumber in 1972 was much higher than in 1970 which resulted in the in-place cost of exterior walls framed with steel being less than that for walls framed with wood. At 1972 materials prices and wages, steel-framed exterior walls cost about $0.16 less per linear foot than wood-framed exterior walls for small volume builders and $0.32 less per linear foot for large volume builders.

COMPARATIVE IN-PLACE COST BETWEEN WOOD AND STEEL RESIDENTIAL FLOOR AND WALL FRAMING

by

Gerald A. Koenigshof [4]

COST OF WOOD AND STEEL FLOOR FRAMING AT 1970 PRICES

This analysis compares in-place costs of floors framed with wood and steel in single-family, site-built homes in Chicago, Los Angeles, and Washington, D. C., in 1970. These cities were selected as the most active residential building areas in the United States.

Because the required thickness of the plywood flooring depends on joist spacing, estimates of costs include the installed cost of single-layer plywood flooring as well as lumber, steel, and labor. Only typical structural lumber grade species groups (Douglas-fir, Douglas-fir larch, hem-fir, and southern pine), grades (No. 2 and Better and Utility or No. 3), and sizes (2x8 and 2x10) used by builders were studied.

Wood Joist Construction

Lumber and plywood quantities.--Amounts of wood framing used in floors varies considerably depending on joist size and spacing, the complexity of the framing system (stairwells, irregularities, etc.), the amount of special framing or blocking required by building codes, and the efficiency of construction. Table 1 summarizes the range of quantities of wood required for framing typical floors.

In the cases cited in table 1 the lowest requirement for framing is with 2x10 floor joists and 24-inch spacing. This apparent advantage is partially offset by higher prices per board foot for 2x10s and by the higher cost of the required thicker flooring.

Plywood requirements ranged between 1.0 and 1.08 square feet per square foot of floor area. The lower amount applies to houses with modular dimensions, no openings in the floor, and no waste or scrap. For this study, a value of 1.06 square feet per square foot was used.

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Table 1.--Quantity of lumber required to frame floors

Nominal joist size	Spacing in inches o.c.	Lumber grade	Simple framing with well-planned usage	Typical house	Complex framing without well-planned usage
			Board feet per square foot of floor 1/		
2x8	16	No. 2 and Better, Douglas-fir or southern pine	1.45	1.55	1.65
2x8	16	No. 3 Hem-fir	1.50	1.70	1.90
2x10	16	No. 2 and Better, Douglas-fir or southern pine	1.55	1.85	2.05
2x10	16	No. 3 Hem-fir and Better	1.85	2.15	2.45
2x10	24	No. 3 and Better, Douglas-fir, Hem-fir, southern pine	1.15	1.25	1.35

1/ Area of openings in floors such as stairwells is not included when computing the board feet per square foot of floor.

Lumber and plywood prices.--Lumber and plywood prices to builders vary by species, grade, region, supply source, and volume of purchase. An attempt was made to take these factors into account in arriving at the estimated builder prices shown in tables 2 and 3. 5/

5/ The appendix includes a detailed analysis of builder prices and factors that affect price change. Tables 30, 31, and 32 in the appendix list prices by species, grade, purchasing practice of builder, and the three cities studied.

Table 2.--Range of estimated prices builders paid for No. 2 or better, S-dry Douglas-fir, Douglas-fir-larch, Hem-fir, or southern pine, 1970

Nominal size	Geographic location of builder	Large volume purchase direct from mill			Large volume purchase from retail yard			Small volume purchase from retail yard		
		Low	Mid	High	Low	Mid	High	Low	Mid	High
		Dollars per M board feet								
2x8	Chicago	127	137	147	133	143	154	144	156	167
	Los Angeles	116	124	133	121	129	139	132	141	151
	Washington, D. C.	117	133	149	122	139	155	133	151	169
2x10	Chicago	136	148	160	142	155	167	155	168	182
	Los Angeles	121	133	146	126	139	153	137	151	166
	Washington, D. C.	126	144	162	132	151	169	143	164	184

Labor quantities.--Labor requirements for installing wood floors vary widely. Variations are attributable to methods and equipment, size of work crew, skill levels, quality of supervision, weather, and other factors.

Industrial engineers have a technique called "effort rating" that adjusts actual measured time to account for variation between workers. In addition, allowances are made for fatigue, unavoidable delays, personal time, and resting. Actual field measured time with the above adjustments and allowances is called "standard time." The estimated labor requirements shown in table 4 are for standard time. These estimates indicate that it takes about two-thirds as much time to frame a floor with 24-inch joist spacing as it does with 16-inch spacing.

Relatively little information is available concerning the amount of labor required to lay plywood floors on wood joists spaced 24 to 48 inches apart. However, there is sufficient data relating to 16-inch spacing that it is possible to develop what appears to be reasonable installation cost estimates for single-layer plywood floor (tongue and grooved) on joists of 24-inch and 48-inch spacing. These estimates are presented in table 5.

Table 3.--Estimated prices builders paid for T&G-2E Underlayment grade plywood with Exterior type adhesive, 1970

Thickness (inches)	Geographic location of builder	Large volume purchase direct from mill	Large volume purchase from retail yard	Small volume purchase from retail yard
		Dollars per thousand square feet		
5/8	Chicago	167	175	190
	Los Angeles	159	166	180
	Washington, D. C.	172	180	195
3/4	Chicago	191	200	217
	Los Angeles	180	188	205
	Washington, D. C.	197	206	224
1 1/8	Chicago	303	317	345
	Los Angeles	287	300	326
	Washington, D. C.	312	326	354

Labor wages.--Wages of construction labor vary considerably between regions. Within any locality, moreover, costs vary according to the mix of skills used. For example, 75 percent of the work in building a house could be done by unskilled labor, but in actual practice house construction is done by skilled or semiskilled labor. Information on combinations of skill levels is limited.

For this report, only two skill levels have been used, carpenter and laborer. It has been further assumed that half of the work is done by skilled carpenters and the other half by laborers. Wage rates for these categories are shown in table 6.

Table 4.--Amount of labor required to frame floors, 1970

Nominal joist size	Spacing in inches o.c.	Simple framing with well-planned usage	Typical house	Complex framing without well-planned usage
		Standard man-minutes per square foot of floor area		
2x8	16	0.40	0.70	1.30
2x8	24	.30	.50	.75
2x10	16	.45	.75	1.35
2x10	24	.35	.55	.80

Table 5.--Amount of labor required to install single layer T&G plywood flooring, 1970

Spacing of floor joist (inches)	Simple framing with well-planned usage	Typical house	Complex framing without well-planned usage
	Standard man-minutes per square foot of floor area		
16	0.28	0.45	0.62
24	.25	.35	.45
48	.18	.26	.34

Table 6.--Wage rates including fringe benefits for wood floor framing in residential construction, 1970 1/

Location	Carpenter wages		Laborer wages	
	Per hour	Per minute	Per hour	Per minute
	Dollars	Dollars	Dollars	Dollars
Chicago	7.95	0.1325	7.00	0.1167
Los Angeles	7.60	.1267	6.40	.1067
Washington, D. C.	4.65	.0775	2.95	.0492

1/ Wage rates obtained from National Association of Home Builders, Labor Division.

Total in-place cost.--Tables 7, 8, and 9 summarize cost calculations for installation of floors supported by wood joists. For each of the three selected cities three situations were simulated:

1. A large volume builder purchasing lumber directly from a sawmill.
2. A large volume builder purchasing lumber from a retail yard.
3. A small volume builder purchasing lumber from a retail yard.

Installed costs for these different situations in 1970 were estimated to range between $0.45 and $0.59 per square foot of floor area. However, the actual range in costs is considerably greater than this because average material and labor requirements per square foot of floor space were used rather than the ranges indicated in tables 1, 4, and 5.

The total in-place cost of fasteners for framing and flooring are usually less than $0.01 per square foot for both wood- and steel-framed floors. Even though the unit cost for screws used in steel floor systems is much higher than the unit cost for wood-framed floor systems, the differential in-place cost for fasteners used in steel- versus wood-framed floors is insignificant (less than 2 percent of the total). This cost is not included in this analysis.

Table 7.--In-place costs per square foot of constructing floors with wood framing and plywood flooring in Chicago, Illinois, 1970

Floor system and type builder	Framing							Plywood flooring							
	Materials			Labor			Total cost per square foot of floor	Materials			Labor			Total cost per square foot of floor	Total in-place cost per square foot of floor
	Per square foot of floor	Price per board foot	Cost per square foot of floor	Per square foot of floor	Wage per man-minute	Cost per square foot of floor		Per square foot of floor	Price per square foot	Cost per square foot of floor	Per square foot of floor	Wage per man-minute	Cost per square foot of floor		
	Board feet	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars	Square feet	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars	Dollars
2x8 joist spaced 16 inches o.c. [1] and 5/8-inch thick plywood flooring [2]															
Large volume builder purchasing lumber directly from mill	1.55	0.137	0.212	0.70	0.1246	0.087	0.299	1.06	0.167	0.177	0.45	0.1246	0.056	0.233	0.532
Large volume builder purchasing lumber from retail yard	1.55	.143	.222	.70	.1246	.087	.309	1.06	.175	.186	.45	.1246	.056	.242	.551
Small volume builder purchasing lumber from retail yard	1.55	.156	.242	.70	.1246	.087	.329	1.06	.190	.201	.45	.1246	.056	.257	.586
2x10 joist spaced 24 inches o.c. [1] and 3/4-inch thick plywood flooring [2]															
Large volume builder purchasing lumber directly from mill	1.25	.148	.185	.55	.1246	.068	.253	1.06	.191	.202	.35	.1246	.044	.246	.499
Large volume builder purchasing lumber from retail yard	1.25	.155	.194	.55	.1246	.068	.262	1.06	.200	.212	.35	.1246	.044	.256	.518
Small volume builder purchasing lumber from retail yard	1.25	.168	.210	.55	.1246	.068	.278	1.06	.217	.230	.35	.1246	.044	.274	.552

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[1] All lumber is assumed to be No. 2 or Better, S-Dry, Species grades are assumed to be Douglas-fir, Douglas-fir-larch; hem-fir or southern pine.

[2] Plywood assumed to be T&G - 2 edges, Underlayment grade, group 1 and 2, with exterior glue. Plywood 1/2-inch thick is minimum thickness permitted for joist spacing of 16 inches o.c. but builders typically use 5/8-inch thickness.

Table 8.--In-place costs per square foot of constructing floors with wood framing and plywood flooring in Los Angeles, California, 1970

Floor system and type builder	Framing							Plywood flooring							Total in-place cost per square foot of floor
	Materials			Labor				Materials			Labor				
	Per square foot of floor	Price per board foot	Cost per square foot of floor	Per square foot of floor	Wage per man-minute	Cost per square foot of floor	Total cost per square foot of floor	Per square foot of floor	Price per square foot	Cost per square foot of floor	Per square foot of floor	Wage per man-minute	Cost per square foot of floor	Total cost per square foot of floor	
	Board feet	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars	Square feet	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars	Dollars
2x8 joist spaced 16 inches o.c. and[1] 5/8"-thick plywood flooring [2]															
Large volume builder purchasing lumber directly from mill	1.55	0.124	0.192	0.70	0.1167	0.082	0.274	1.06	0.159	0.169	0.45	0.1167	0.052	0.221	0.495
Large volume builder purchasing lumber from retail yard	1.55	.129	.200	.70	.1167	.082	.282	1.06	.166	.176	.45	.1167	.052	.228	.510
Small volume builder purchasing lumber from retail yard	1.55	.141	.219	.70	.1167	.082	.301	1.06	.180	.191	.45	.1167	.052	.243	.544
2x10 joist spaced 24 inches o.c. and[1] 3/4"-thick plywood flooring [2]															
Large volume builder purchasing lumber directly from mill	1.25	.133	.166	.55	.1167	.064	.230	1.06	.180	.191	.35	.1167	.041	.232	.462
Large volume builder purchasing lumber from retail yard	1.25	.139	.174	.55	.1167	.064	.238	1.06	.188	.199	.35	.1167	.041	.240	.478
Small volume builder purchasing lumber from retail yard	1.25	.151	.189	.55	.1167	.064	.253	1.06	.205	.217	.35	.1167	.041	.258	.511

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[1] All lumber is assumed to be No. 2 or Better, S-Dry. Species grades are assumed to be Douglas-fir, Douglas-fir-larch; hem-fir or southern pine.

[2] Plywood assumed to be T&G - 2 edges, Underlayment grade, group 1 and 2, with exterior glue. Plywood 1/2-inch thick is minimum thickness permitted for joist spacing of 16 inches o.c. but builders typically use 5/8-inch thickness.

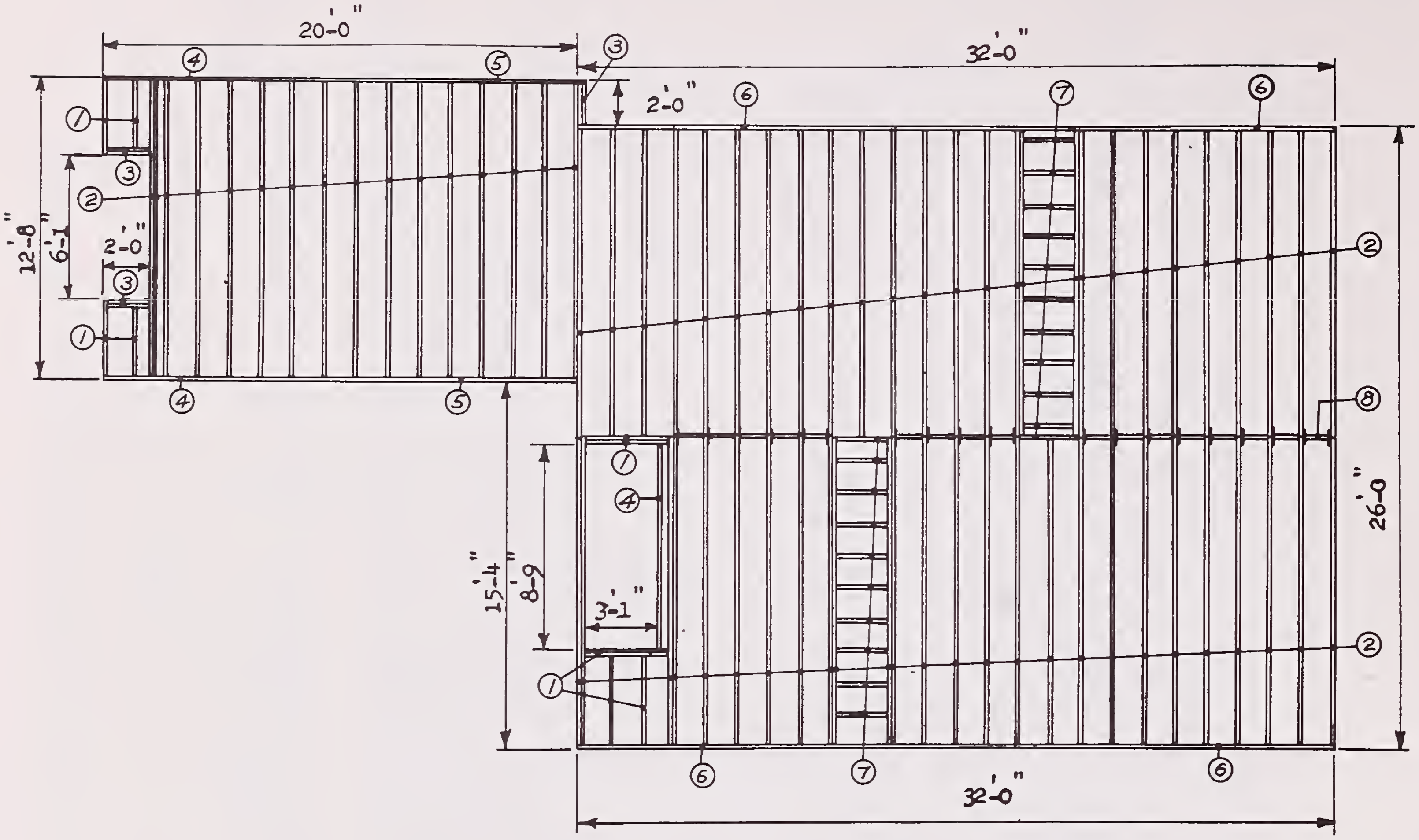
Table 9.--In-place costs per square foot of constructing floors with wood framing and plywood flooring in Washington, D. C., 1970

	Framing							Plywood flooring							
	Materials			Labor				Materials			Labor				
	Per square foot of floor	Price per board foot	Cost per square foot of floor	Per square foot of floor	Wage per man-minute	Cost per square foot of floor	Total cost per square foot of floor	Per square foot of floor	Price per square foot	Cost per square foot of floor	Per square foot of floor	Wage per man-minute	Cost per square foot of floor	Total cost per square foot of floor	Total in-place cost per square foot of floor
	Board feet	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars	Square feet	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars	Dollars
2x8 joist spaced 16 inches o.c.[1] and 5/8-inch thick plywood flooring [2]															
Large volume builder purchasing lumber directly from mill	1.55	0.133	0.206	0.70	0.0633	0.044	0.250	1.06	0.172	0.182	0.45	0.0633	0.028	0.210	0.460
Large volume builder purchasing lumber from retail yard	1.55	.139	.215	.70	.0633	.044	.259	1.06	.180	.191	.45	.0633	.028	.219	.478
Small volume builder purchasing lumber from retail yard	1.55	.151	.234	.70	.0633	.044	.278	1.06	.195	.207	.45	.0633	.028	.235	.513
2x10 joist spaced 24 inches o.c.[1] and 3/4-inch thick plywood flooring [2]															
Large volume builder purchasing lumber directly from mill	1.25	.144	.180	.55	.0633	.035	.215	1.06	.197	.209	.35	.0633	.022	.231	.446
Large volume builder purchasing lumber from retail yard	1.25	.151	.189	.55	.0633	.035	.224	1.06	.206	.218	.35	.0633	.022	.240	.464
Small volume builder purchasing lumber from retail yard	1.25	.164	.205	.55	.0633	.035	.240	1.06	.240	.237	.35	.0633	.022	.259	.499

[1] All lumber is assumed to be No. 2 or Better, S-Dry. Species grades assumed to be Douglas-fir, Douglas-fir-larch, hem-fir, or southern pine.

[2] Plywood is assumed to be T&G - 2 edges, underlayment grade, group 1 and 2, with exterior glue. Plywood 1/2-inch thick is minimum thickness permitted for joist spacing of 16 inches o.c. but builders typically use 5/8-inch thickness.

Floor Area = 1,047 Sq Ft



Floor Framed with Wood

Figure 1.--Floor framed with wood. Circled numbers refer to items presented in table 10.

Steel Joist Construction

Steel and plywood quantities.--The material requirements for steel joist floors were estimated by "reframing" five floor plans using typical wood joists with steel joists. The steel framing system for the five floors used the most economical joist sizes, configurations, and spacings, because this is more typical of construction practices by builders that have adopted steel framing. Figure 1 illustrates a typical wood floor and table 10 lists quantities of wood for the floor. Figure 2 and table 11 provide similar information for steel when the floor was "reframed."

With 2x8 18-gage steel joists spaced 24 inches on center, the amount of steel required varied between 1.68 and 2.00 pounds per square foot, averaging 1.85 pounds per square foot. With floors framed with 2x8 14-gage steel joists spaced 48 inches on center, amounts of steel varied between 1.94 and 2.62 pounds per square foot, with an average of 2.15 pounds per square foot.

Table 10.--Lumber required to frame floor in figure 1

Circled item, figure 1	Lumber required		
	Quantity	Size	Board feet
1	10	2x8 - 4	53.3
2	68	2x8 - 14	1269.6
3	5	2x8 - 10	66.6
4	3	2x8 - 10	40.0
5	2	2x8 - 12	32.0
6	4	2x8 - 16	85.3
7	3	2x8 - 14	56.0
8	2	2x8 - 12	32.0
		Total	1634.8

$$\frac{1634.8}{1047.0} = 1.56 \text{ board feet per square foot}$$

The "reframing" in each case included steel double band joists under exterior load bearing walls and at the edges of stairwell openings. It also included an additional joist along the edge of floor openings under plumbing walls. Short members used in "ladder" framing or around openings for heating or plumbing components were steel.

The amounts in figure 2 do not include foundation sill plates which were assumed to be wood. Neither are joist hangers, framing clips, or steel joist stiffeners included in the above amounts. The weights of these accessory items ranged from 0.070 to 0.125 pound of steel per square foot, for 18-gage nominal 2x8 joists spaced 24 inches on center, depending on the complexity of the floor framing arrangement. For 14-gage nominal 2x8 joists spaced 48 inches on center, these items weighed from 0.045 to 0.085 pound per square foot.

Table 11.--Steel required to frame floor in figure 2

Circled item, figure 2	Steel required		
	Quantity	Length-feet	Pounds of steel
1	10	12.3	250.9
2	2	3.1	12.6
3	2	1.9	7.8
4	4	20.0	163.2
5	2	1.9	7.8
6	15	25.7	786.5
7	4	32.0	261.1
8	1	12.7	25.9
9	1	3.7	7.6
10	4	3.7	30.2
11	1	8.8	17.9
12	6	13.2	161.6
13	16	4.0	130.6
		Total	1863.7

$$\frac{1863.7}{1047.0} = 1.78 \text{ pounds per square foot}$$

Special metal screws are required to fasten together steel framing, but this cost was not included in the estimates because it represents less than 1 percent of the total cost. The cost per pound for these special screws is significantly higher than the per pound cost of nails used in wood floors but fewer are used. The net result is that total cost of steel versus wood floors is not significantly affected by fastener cost.

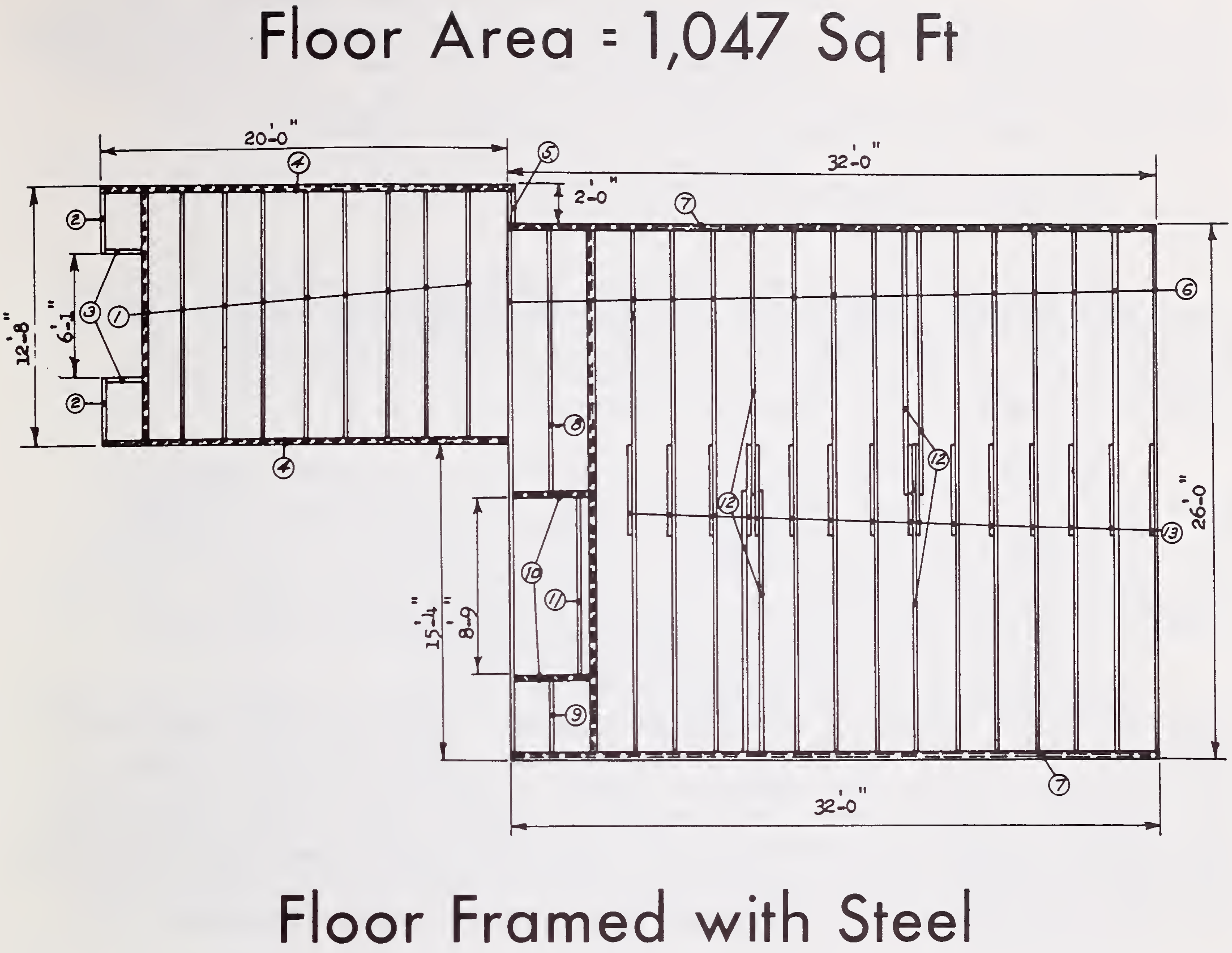


Figure 2.--Floor framed with steel. Circled numbers refer to items presented in table 11.

In summary, the steel requirements used in the cost calculations were:

Framing item	24-inch spacing 18 gage	48-inch spacing 14 gage
	(Pounds per square foot of floor framed with 2x8 joists)	
Joists	1.850	2.150
Fasteners and other accessories	0.095	0.065
Total	1.945	2.215

The amounts of steel are for highly efficient steel joist systems. However, less steel can and has been used in actual practice. Common practice in steel joist construction is to frame around openings with wood. In steel construction, joist lengths equal to the width of the house are used to achieve continuity over intermediate supports, thus reducing deflection.

The amount of plywood in floors with steel joists is the same as in floors with wood joists of the same spacing.

Steel and plywood prices.--Table 12 shows typical delivered costs of steel joist framing. Steel-producing facilities are fairly well distributed throughout the United States and are located in practically every major metropolitan area; thus, there are no great differences in steel prices because of distances from producing facilities.

The method of distribution is one of the most important causes of price differences. Fourteen-gage steel floor joists purchased in large quantities (40,000 pounds or more) direct from the rolling mill apparently cost about $0.133 per pound in 1970. Purchased from a local steel distribution center in large volume, the price was about $0.166 per pound. The cost spread for 18-gage steel joists is between $0.148 and $0.184 per pound.

Labor quantities.--Relatively little information is available on labor requirements for installing steel floor framing. Some industrial engineers state that labor costs of framing with steel are higher than with wood. On the other hand, steel firms advertise claims of less installation time with steel joists. These latter claims may not be supportable because traditional wood floors can also be constructed with material layouts that are well planned by engineers rather than by carpenters. Also, portions of the steel-framed floor are often framed with wood, and this labor may not be reported.

Table 12.--Estimated prices paid by builders for steel floor joists, 1970

Gage	Large volume purchased direct from rolling mill	Large volume purchased from local distribution center
	Dollars per pound	
18	0.1475	0.1844
16	.1412	.1765
14	.1329	.1661

Studies by the USDA Forest Service indicate that time for labor to install steel or wood framing is about the same. That assumption was followed in this analysis as indicated in tables 13 and 4.

Labor requirements for installing plywood floor over steel joists were estimated to be the same as over wood joists (table 5).

Table 13.--Labor requirements for installing steel joist framing, 1970

Steel joist spacing in inches o.c.	Simple framing	Typical framing	Complex framing
	Standard man-minute per square foot of floor		
24	0.30	0.50	0.75
48	.22	.32	.42

Labor wages.--Currently steel floors are installed by carpentry crews that frame other parts of a house. The wages paid to carpenters and laborers for installing steel floors were, therefore, assumed to be the same as for installing wood floors.

Total in-place cost.--The in-place cost of floors with all steel framing and plywood flooring ranges between $0.56 and $0.78 per square foot of floor. Tables 14, 15, and 16 show the range in materials and labor cost by type of builder and metropolitan area. The lower prices apply to builders who can purchase in large volume directly from the steel rolling mill and plywood plant. Floor systems with 48-inch spacing of joists tend to be more costly because thick flooring is required.

Tables 14, 15, and 16 do not include additional costs of special screws used with steel or for wood sill plates that are sometimes used to supplement the steel framing system.

Small volume builders who prefer to purchase materials for a single house at a time would probably have to pay as much as 20 to 25 percent more than shown in the tables.

Table 14.--In-place costs per square foot of constructing floors with steel framing and plywood flooring in Chicago, Illinois, 1970

Floor system and type builder	Framing							Plywood flooring							Total in-place cost per square foot of floor
	Materials			Labor			Total cost per square foot of floor	Materials			Labor			Total cost per square foot of floor	
	Per square foot of floor	Price per pound	Cost per square foot of floor	Per square foot of floor	Wage per man-minute	Cost per square foot of floor		Per square foot of floor	Price per square foot	Cost per square foot of floor	Per square foot of floor	Wage per man-minute	Cost per square foot of floor		
	Pounds	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars	Square feet	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars	Dollars
Nominal 2x8, 18-gage joist spaced 24 inches o.c.1/ and 3/4-inch thick plywood flooring 2/															
Large volume builder purchasing directly from rolling or plywood mill:															
Joist	1.85	0.1475	0.273												
Accessories	.095	.25	.024												
Total			.297	.50	0.1246	0.062	0.359	1.06	0.191	0.202	0.35	0.1246	0.044	0.245	0.605
Large volume builder purchasing from distribution yard:															
Joist	1.85	.1844	.341												
Accessories	.095	.25	.024												
Total			.365	.50	.1246	.062	.427	1.06	.200	.212	.35	.1246	.044	.256	.683
Nominal 2x8, 14-gage joist spaced 48 inches o.c. 1/ and 1 1/8-inch thick plywood flooring 2/															
Large volume builder purchasing directly from rolling or plywood mill:															
Joist	2.15	.1329	.286												
Accessories	.065	.25	.016												
Total			.302	.32	.1246	.040	.342	1.06	.303	.321	.26	.1246	.032	.353	.695
Large volume builder purchasing from distribution yard:															
Joist	2.15	.1661	.357												
Accessories	.065	.25	.016												
Total			.373	.32	.1246	.040	.413	1.06	.317	.335	.26	.1246	.032	.367	.780

1/ Light-gage hot-dipped galvanized coil stock with minimum yield stress of 40,000 psi.

2/ Plywood is assumed to be T&G - 2 edges, underlayment grade, group 1 or 2, with exterior glue.

Table 15.--In-place labor and materials cost per square foot of constructing floors with steel framing and plywood flooring in Los Angeles, California, 1970

Floor system and type builder	Framing							Plywood flooring							Total in-place cost per square foot of floor
	Materials			Labor			Total cost per square foot of floor	Materials			Labor			Total cost per square foot of floor	
	Per square foot of floor	Price per pound	Cost per square foot of floor	Per square foot of floor	Wage per man-minute	Cost per square foot of floor		Per square foot of floor	Price per square foot	Cost per square foot of floor	Per square foot of floor	Wage per man-minute	Cost per square foot of floor		
	Pounds	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars	Square feet	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars	Dollars
Nominal 2x8, 18-gage joist spaced 24 inches o.c. 1/ and 3/4-inch thick plywood flooring 2/															
Large volume builder purchasing directly from rolling or plywood mill:															
Joist	1.85	0.1475	0.273												
Accessories	0.095	0.25	.024												
Total			.297	0.50	0.1167	0.058	0.355	1.06	0.180	0.191	0.35	0.1167	.041	0.232	0.587
Large volume builder purchasing from distribution yard:															
Joist	1.85	.1844	.341												
Accessories	.095	.25	.024												
Total			.365	.50	.1167	.058	.423	1.06	.188	.199	.35	.1167	.041	.240	.663
Nominal 2x8, 14-gage joist spaced 48 inches o.c. 1/ and 1 1/8-inch thick plywood flooring 2/															
Large volume builder purchasing directly from rolling or plywood mill:															
Joist	2.15	.1329	.286												
Accessories	.065	.25	.016												
Total			.302	.32	.1167	.037	.339	1.06	.287	.304	.26	.1167	.030	.334	.673
Large volume builder purchasing from distribution yard:															
Joist	2.15	.1661	.357												
Accessories	.065	.25	.016												
Total			.373	.32	.1167	.037	.410	1.06	.300	.318	.26	.1167	.030	.348	.758

1/ Light-gage hot-dipped galvanized coil stock with minimum yield stress of 40,000 psi.

2/ Plywood is assumed to be T&G - 2 edges, underlayment grade, group 1 or 2, with exterior glue.

Table 16.--In-place labor and materials cost per square foot of constructing floors with steel framing and plywood flooring in Washington, D. C., 1970

Floor system and type builder	Framing							Plywood flooring							Total in-place cost per square foot of floor
	Materials			Labor			Total cost per square foot of floor	Materials			Labor			Total cost per square foot of floor	
	Per square foot of floor	Price per pound	Cost per square foot of floor	Per square foot of floor	Wage per man-minute	Cost per square foot of floor		Per square foot of floor	Price per square foot	Cost per square foot of floor	Per square foot of floor	Wage per man-minute	Cost per square foot of floor		
	Pounds	Dollars	Man-minutes	Dollars	Dollars	Dollars	Dollars	Square feet	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars	Dollars
Nominal 2x8, 18-gage joist spaced 24 inches o.c. 1/ and 3/4-inch plywood flooring 2/															
Large volume builder purchasing directly from rolling or plywood mill:															
Joist	1.85	0.1475	0.273												
Accessories	0.095	0.25	0.024												
Total			0.297	0.50	0.0633	0.032	0.329	1.06	0.197	0.209	0.35	0.0633	.022	0.231	0.560
Large volume builder purchasing from distribution yard:															
Joist	1.85	0.1844	0.341												
Accessories	0.095	0.25	0.024												
Total			0.365	0.50	0.0633	0.032	0.397	1.06	0.206	0.218	0.35	0.0633	.022	0.240	0.637
Nominal 2x8, 14-gage joist spaced 48 inches o.c. 1/ and 1 1/8-inch thick plywood flooring 2/															
Large volume builder purchasing directly from rolling or plywood mill:															
Joist	2.15	0.1329	0.286												
Accessories	0.065	0.25	0.016												
Total			0.302	0.32	0.0633	0.020	0.322	1.06	0.312	0.331	0.26	0.0633	.016	0.347	0.669
Large volume builder purchasing from distribution yard:															
Joist	2.15	0.1661	0.357												
Accessories	0.065	0.25	0.016												
Total			0.373	0.32	0.0633	0.020	0.393	1.06	0.326	0.346	0.26	0.0633	.016	0.362	0.755

1/ Light-gage hot-dipped galvanized coil stock with minimum yield stress of 40,000 psi.

2/ Plywood is assumed to be T&G - 2 edges, underlayment grade, group 1 or 2, with exterior glue.

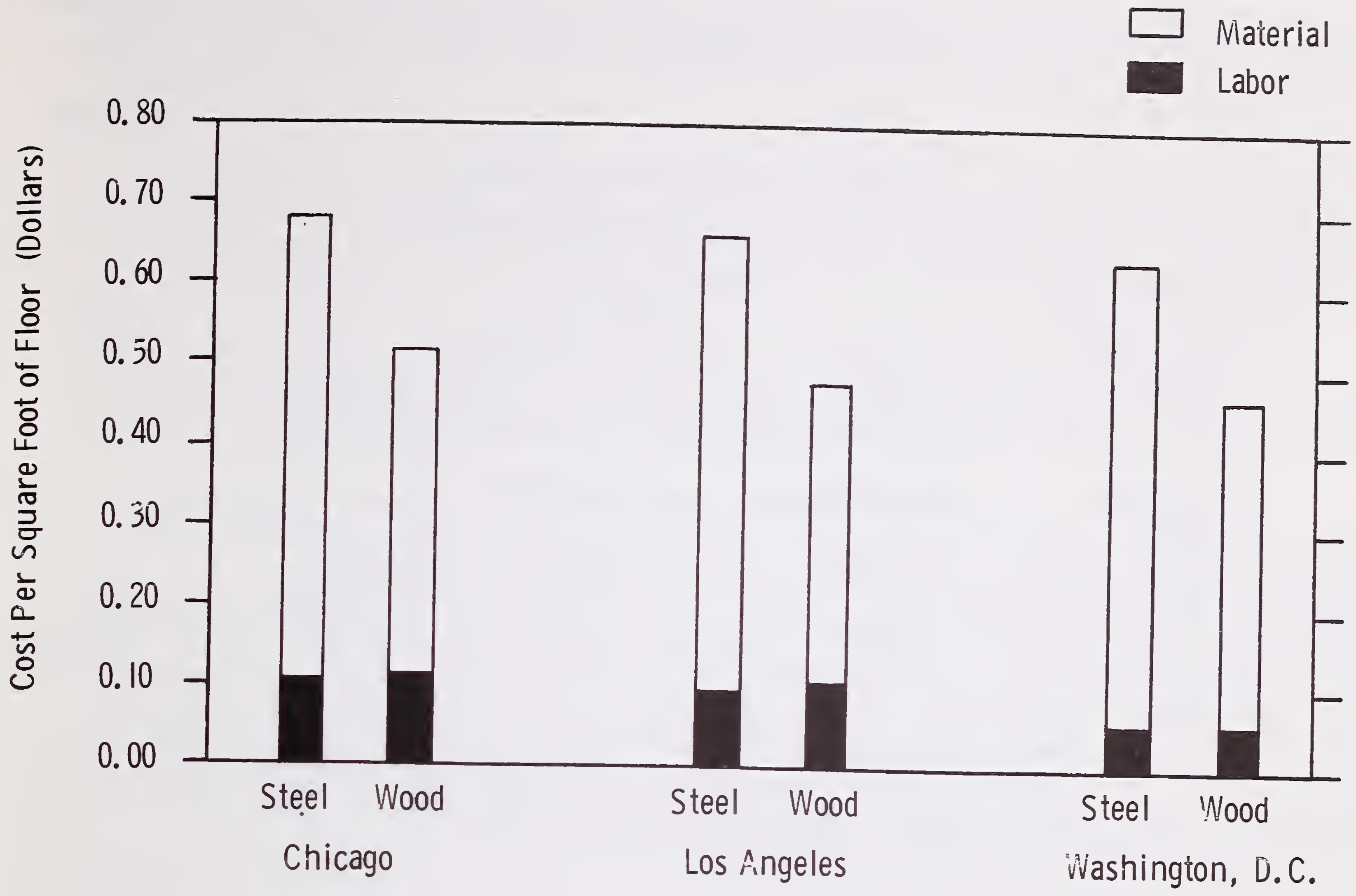


Figure 3.--Comparative in-place costs for both nominal 2x10 wood and 2x8 steel joists spaced 24 inches on center, purchased in large volume through local retail outlets. Both steel and wood floors use 3/4-inch thick plywood flooring.

As shown in figure 3, costs of wood joist systems were lower than those for steel joist systems. Differences in costs per square foot for large builders purchasing through retail outlets, for example, were estimated as follows:

City	Steel construction (dollars)	Wood construction (dollars)	Difference	
			Per sq. ft. (dollars)	Percent
Chicago	0.68	0.55	0.13	24
Los Angeles	0.66	0.51	0.15	29
Washington, D. C.	0.64	0.48	0.16	33

In addition to differences in installed costs, materials use also is determined by certain nonprice factors. Both lumber and steel have their competitive problems in the market for floor joists in single-family housing.

A disadvantage of lumber, for example, is that builders use more wood than necessary, because of both tradition and building codes. Unnecessary lumber use may include bridging,double layer floors, solid blocking between joists over center supports, sill plates on top of foundation walls and girders, and larger band joists or girders than required by engineering analysis. In contrast, most steel joist installations have been carefully designed to use minimum amounts of material consistent with good performance and ease of construction. Lumber prices also fluctuate more widely than steel prices, causing greater uncertainty in cost estimates.

On the other hand, there is no complete distribution system for steel suitable for the housing industry. Most sales of steel are made to large volume builders, with considerable lead time required for delivery.

In contrast, the lumber industry has a well-developed distribution system of wholesalers and retailers. Moreover, steps have been taken in recent years to simplify and reduce costs of lumber distribution.
In the large metropolitan areas, retail lumber yards often purchase directly from mills. The amount of lumber being handled by large lumber producers that have established mill-owned warehouses in large eastern cities has increased while the amount handled by independent wholesalers has tended to decline. Builders in some areas obtain large discounts by purchasing directly from mills. Thus, the trend is toward increased efficiency in a lumber distribution system that makes lumber widely and readily available. The steel industry presently lacks such a system.

COST OF WOOD AND STEEL WALL FRAMING AT 1970 PRICES

This analysis compares in-place costs of wood and steel wall framing in single-family, site-built homes in Chicago, Los Angeles, and Washington, D. C., in 1970, and factors influencing these costs. Costs of wall facing (wallboard and other materials) are not included since cost of these items is essentially the same for either wood or steel construction. Linear footage of walls is defined to include window and door opening widths except where full ceiling height doors are used.

Wood Stud Construction

Lumber quantities.--The amount of lumber used to frame both nonload bearing and load-bearing walls varies considerably according to stud size (usually 2x3 or 2x4); stud spacing (usually 16 or 24 inches); number and size of doors, windows, and other openings; framing and blocking used; and efficiency in use of materials.

Table 17 shows that between 3.85 and 7.68 board feet of lumber per linear foot of wall are typically used in nonload-bearing walls.

The range for load-bearing walls is from 6.33 to 10.12 board feet per linear foot.

Table 17.--Quantity per linear foot of lumber typically used to frame nonload-bearing interior partitions and load-bearing exterior walls

Nonload-bearing partitions

Nominal stud size	Stud spacing in inches	Simple framing with well-planned usage	Typical house	Complex framing without well-planned usage
		Board feet	Board feet	Board feet
2x3	16	4.32	5.04	5.76
2x3	24	3.85	4.54	5.23
2x4	16	5.76	6.72	7.68
2x4	24	5.18	6.11	7.03

Load-bearing exterior walls

Nominal stud size	Stud spacing in inches	Simple framing with well-planned usage	Typical house	Complex framing without well-planned usage
2x4	16	6.84	8.48	10.12
2x4	24	6.33	7.65	8.96

Lumber prices--Table 18 shows estimated prices paid by builders for wood studs in the three selected cities. Prices are for Douglas fir, Douglas-fir-larch, Hem-fir, and Southern Pine S-dry stud grades. Price differences between species grades were about $3 per 1,000 board feet, except for Southern Pine in Washington, D. C., which was substantially less than for other species. The price for 2x3 studs was essentially the same as for 2x4 studs. Some years ago 2x3 studs cost about $10 less per $1,000 board feet than 2x4 studs at the mill; but in 1970, the cost of 2x3 studs ranged from about $3 less to $3 more than that of 2x4 studs. A detailed analysis of builder prices for stud lumber is presented in the appendix.

Labor quantities.--The labor required in framing walls with wood varies considerably depending on the complexity of the construction and efficiency of operations. Some labor cost savings may be achieved by using 2x3 studs instead of 2x4's because the smaller studs are a little more easily handled and require slightly less sawing time. Table 19 shows labor requirements per linear foot of wall.

Table 18.--Range of estimated prices builders paid for 2x3 and 2x4 stud grade wall framing in 1970

Location	Large volume purchased direct from mill	Large volume purchased from retail yard	Small volume purchased from retail yard
	Dollars per thousand board feet		
Chicago	114	119	129
Los Angeles	100	105	114
Washington, D. C. 1/	117	122	133
	(100)	(105)	(114)

1/ Prices in parentheses are for southern pine.

Labor wages.--Wage rates in Washington in 1970 were much lower than in Chicago and Los Angeles, as table 20 shows. Highly skilled carpenters are usually employed to install partitions or walls, although unskilled labor could do most of the work. The mix of skill levels is not well defined hence it was assumed that half the labor required to frame walls is by carpenters and half by laborers.

Total in-place cost.--Tables 21, 22, and 23 summarize the cost calculations for wood framing in the three selected cities. In addition to taking account of variations in stud size, stud spacing, and labor cost differentials, estimates were developed for three other situations, including:

1. A large volume builder purchasing lumber directly from a sawmill.
2. A large volume builder purchasing lumber from a retail yard.
3. A small volume builder purchasing lumber from a retail yard.

In-place costs in dollars per linear foot varied in 1970 between $0.87 and $1.68 for nonload-bearing partitions and between $1.27 and $1.88 for load-bearing exterior walls.

Table 19.--Quantity of labor per linear foot of wall including window and door widths except where full ceiling height doors are used

Nonload bearing partitions

Nominal stud size	Stud spacing in inches	Simple framing with well-planned usage	Typical house	Complex framing without well-planned usage
		Man-minutes	Man-minutes	Man-minutes
2x3	16	4.46	6.20	7.94
2x4	16	4.69	6.51	8.33
2x3	24	4.00	5.33	6.66
2x4	24	4.20	5.60	7.00

Load-bearing exterior walls

Nominal stud size	Stud spacing in inches	Simple framing with well-planned usage	Typical house	Complex framing without well-planned usage
2x4	16	4.54	6.30	8.06
2x4	24	4.31	5.98	7.47

Table 20.--Wage rates including fringe benefits for wood wall framing in residential construction, 1970 1/

Location	Carpenter wages		Laborer wages	
	Per hour	Per minute	Per hour	Per minute
	Dollars	Dollars	Dollars	Dollars
Chicago	7.95	0.1325	7.00	0.1167
Los Angeles	7.60	.1267	6.40	.1067
Washington, D. C.	4.65	.0775	2.95	.0492

1/ Wage rates obtained from National Association of Home Builders, Labor Division.

Table 21.--In-place costs of wood framing per linear foot of nonload-bearing partitions and exterior load-bearing walls[1] in Chicago, 1970

Type builder and wall framing			Materials			Labor			Total in-place cost per linear foot
Type builder	Normal stud size	Stud spacing in inches	Per linear foot	Price per board foot	Cost per linear foot	Per linear foot	Wage per man-minute	Cost per linear foot	
			Board feet	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars
	Partitions								
Large volume builder purchasing lumber directly from mill	2x3	16	5.04	0.114	0.575	6.20	0.1246	0.773	1.348
	2x4	16	6.72	.114	.766	6.51	.1246	.811	1.577
	2x3	24	4.54	.114	.518	5.33	.1246	.664	1.182
	2x4	24	6.11	.114	.697	5.60	.1246	.698	1.359
	Exterior walls								
	2x4	16	8.48	.114	.967	6.30	.1246	.785	1.752
	2x4	24	7.65	.114	.872	5.98	.1246	.745	1.617
	Partitions								
Large volume builder purchasing lumber from retail yard	2x3	16	5.04	.119	.600	6.20	.1246	.773	1.373
	2x4	16	6.72	.119	.800	6.51	.1246	.811	1.611
	2x3	24	4.54	.119	.540	5.33	.1246	.664	1.204
	2x4	24	6.11	.119	.727	5.60	.1246	.698	1.425
	Exterior walls								
	2x4	16	8.48	.119	1.009	6.30	.1246	.785	1.794
	2x4	24	7.65	.119	.910	5.98	.1246	.745	1.655
	Partitions								
Small volume builder purchasing lumber from retail yard	2x3	16	5.04	.129	.650	6.20	.1246	.773	1.423
	2x4	16	6.72	.129	.867	6.51	.1246	.811	1.678
	2x3	24	4.54	.129	.586	5.33	.1246	.664	1.250
	2x4	24	6.11	.129	.788	5.60	.1246	.698	1.486
	Exterior walls								
	2x4	16	8.48	.129	1.094	6.30	.1246	.785	1.879
	2x4	24	7.65	.129	.987	5.98	.1246	.745	1.732

---

[1] Includes door and window openings except door openings extending to the ceiling.

Table 22.--In-place costs of wood framing per linear foot of nonload-bearing partitions and exterior load-bearing walls[1] in Los Angeles, 1970

Type builder and wall framing			Materials			Labor			Total in-place cost per linear foot
Type builder	Nominal stud size	Stud spacing in inches	Per linear foot	Price per board foot	Cost per linear foot	Per linear foot	Wage per man-minute	Cost per linear foot	
			Board feet	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars
	Partitions								
Large volume builder purchasing lumber directly from mill	2x3	16	5.04	0.100	0.504	6.20	0.1167	0.724	1.228
	2x4	16	6.72	.100	.672	6.51	.1167	.750	1.432
	2x3	24	4.54	.100	.454	5.33	.1167	.622	1.076
	Exterior walls								
	2x4	16	8.48	.100	.848	6.30	.1167	.735	1.583
	2x4	24	7.65	.100	.765	5.98	.1167	.698	1.463
	Partitions								
Large volume builder purchasing lumber from retail yard	2x3	16	5.04	.105	.529	6.20	.1167	.724	1.253
	2x4	16	6.72	.105	.706	6.51	.1167	.760	1.466
	2x3	24	4.54	.105	.477	5.33	.1167	.622	1.099
	2x4	24	6.11	.105	.642	5.60	.1167	.654	1.296
	Exterior walls								
	2x4	16	8.48	.105	.890	6.30	.1167	.735	1.625
	2x4	24	7.65	.105	.803	5.98	.1167	.698	1.501
	Partitions								
Small volume builder purchasing lumber from retail yard	2x3	16	5.04	.114	.575	6.20	.1167	.724	1.299
	2x4	16	6.72	.114	.766	6.51	.1167	.760	1.526
	2x3	24	4.54	.114	.518	5.33	.1167	.622	1.140
	2x4	24	6.11	.114	.697	5.60	.1167	.654	1.351
	Exterior walls								
	2x4	16	8.48	.114	.967	6.30	.1167	.735	1.702
	2x4	24	7.65	.114	.872	5.98	.1167	.698	1.570

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[1] Includes door and window openings except door openings extending to the ceiling.

Table 23.--In-place costs of wood framing per linear foot of nonload-bearing partitions and exterior load-bearing walls[1] in the Washington, D.C., metropolitan area during 1970

Type builder and wall framing			Materials			Labor			Total in-place cost per linear foot
Type builder	Nominal stud size	Stud spacing in inches	Per linear foot	Price per board foot	Cost per linear foot	Per linear foot	Wage per man-minute	Cost per linear foot	
			Board feet	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars
	Partitions								
Large volume builder purchasing lumber directly from mill	2x3	16	5.04	0.117	0.590	6.20	0.0634	0.393	0.983
	2x4	16	6.72	.117	.786	6.51	.0634	.413	1.199
	2x3	24	4.54	.117	.531	5.33	.0634	.338	0.869
	2x4	24	6.11	.117	.715	5.60	.0634	.355	1.070
	Exterior walls								
	2x4	16	8.48	.117	.992	6.30	.0634	.399	1.391
	2x4	24	7.65	.117	.895	5.98	.0634	.379	1.274
	Partitions								
Large volume builder purchasing lumber from retail yard	2x3	16	5.04	.122	.615	6.20	.0624	.393	1.008
	2x4	16	6.72	.122	.820	6.51	.0634	.413	1.233
	2x3	24	4.54	.122	.554	5.33	.0634	.338	0.892
	2x4	24	6.11	.122	.745	5.60	.0634	.355	1.101
	Exterior walls								
	2x4	16	8.48	.122	.035	6.30	.0634	.399	1.434
	2x4	24	7.65	.122	.933	5.98	.0634	.379	1.312
	Partitions								
Small volume builder purchasing lumber from retail yard	2x3	16	5.04	.133	.670	6.20	.0634	.393	1.063
	2x4	16	6.72	.133	.894	6.51	.0634	.413	1.307
	2x3	24	4.54	.133	.604	5.33	.0634	.338	0.942
	2x4	24	6.11	.133	.813	5.60	.0634	.355	1.168
	Exterior walls								
	2x4	16	8.48	.133	1.128	6.30	.0634	.399	1.527
	2x4	24	7.65	.133	1.017	5.98	.0634	.379	1.396

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[1] Includes door and window openings except door openings extending to the ceiling.

Steel quantities.--The amount of 26-gage steel required for nonload-bearing partitions ranged between 2.4 and 5.1 pounds per linear foot of partitions, according to published trade data. Exterior load-bearing walls require between 6.5 and 10.5 pounds of steel studs per linear foot.

In actual practice the quantity of steel studs used for framing nonload-bearing interior walls does not vary as much as the above figures indicate. A more typical range is between 2.4 and 3.7 pounds per linear foot because 16-inch spacing and the larger 2x4 studs are seldom used for this purpose.

If steel is to be accepted by builders to meet the requirements of building codes, closer spacing or studs of heavier gage may be necessary. Steel studs of 2x2 and 2x3 sizes have less axial and bending strength than wood studs of the same sizes, and if spaced 24 inches on center, they fail to meet Federal Housing Administration Minimum Property Standard (MPS-300) bending load requirements. The top portion of table 24 lists quantities of steel required to frame nonload-bearing partitions.

Wall facing material, usually gypsum board, is not included in the quantities of material (table 24). If wood or steel studs are spaced 16 inches on center, 3/8-inch thick gypsum wallboard is permissible. If studs are spaced 24 inches on center, 1/2-inch thick gypsum wallboard is used. When cost comparisons include cost of facing materials, it is necessary to compare systems with equal stud spacings so the cost of the facing does not incorrectly bias the results.

The steel framing that is available for exterior walls meets Federal Housing Administration specifications. Exterior load-bearing steel studs are available in a variety of sizes, shapes, and gages. Usually, the width is about 1 1/2 inches; depth varies between 2 1/2 and 4 inches. Configuration is usually U- or C-shaped. Gages are typically 16, 18, or 20. Because there is such a variety of sizes, shapes, and gages available, it is relatively easy to select a configuration that most efficiently uses steel. If the spacing or loading on a stud changes, it is possible to select, from design tables, a stud with the least weight of steel that is structurally adequate.

Wood 2x4 studs, on the other hand, are constant in size and regardless of loading the same amount of lumber is used. Steel is unlike wood exterior wall framing with regard to size and shape. With wood framing there is basically one size (2x4) and one shape (rectangular) for both 16- and 24-inch spacing of studs. With steel numerous configurations (sizes, shapes, and gages) are available. Selection of steel stud configuration is based on design loads, size of house, and stud spacing; therefore, the choice cannot be neatly catagorized as 2x4 on 16- or 24-inch spacing as with wood. Essentially, this means there are several cost/effective configurations for each size house (table 24).

Table 24.--Quantities of steel used for wall framing

Nonload-bearing partitions

Nominal stud size	Spacing in inches	Simple framing with well-planned usage	Typical house	Complex framing without well-planned usage
		Pounds per linear foot 1/		
2x2	16	2.66	3.02	3.38
2x3	16	3.30	3.75	4.19
2x4	16	3.97	4.52	5.06
2x2	24	2.39	2.76	3.13
2x3	24	2.86	3.30	3.74
2x4	24	3.46	3.99	4.53

Load-bearing exterior walls

Studs	Small house with small floor and roof loads	Typical house	Large house with large floor and roof loads
	Pounds per linear foot 1/		
May be C-shaped; types 16-, 18-, and 20-gage; and 16- or 24-inch spacing	6.50	8.50	10.50

1/ Linear measurements include door and window openings, excluding openings of ceiling height.

Steel prices.--Table 25 shows the calculated cost of steel wall framing expressed in dollars per pound. It is possible to use several gages of steel for wall studs, but for purposes of simplicity partition studs were assumed to be 26 gage and exterior wall studs to be 20 gage. (See appendix for price details.)

Labor quantities--The great advantage of steel studs is ease of installation. Labor required to install light-gage (26) steel partition studs is about 50 percent of that required to install wood parition studs. The size of the stud has little effect on time required for installation.

Less time is required for three reasons. First, installation is simpler--steel tracks are fastened to the floor and ceiling and then studs are twisted into position in the track. Secondly, studs are precut to length and adjusted to variations of floor to ceiling height in the track, whereas wood studs have to be well fitted between the top and bottom plates. An electric drill or pneumatic screw driver makes installation of the fasteners very rapid. Thirdly, fasteners (screws) for steel studs are spaced wider than is permitted with nails. Often the ends of the studs are not fastened to the tracks. Instead, the fasteners through the facings hold the studs in place.

Steel studs do not offer the same advantage in exterior load-bearing walls. Installation can be either more or less expensive than for wood studs. Builders require different tools, and crews must be re-trained. Fastening time can be reduced when steel-framed walls are built as panels using automatic "mig" welding or automatic screw machines. Cutting and bending of parts at a central location with proper steel cutting and bending equipment also

Table 25.--Estimated costs of light gage steel stud framing, 1970

Gage	Base price	Thickness adjustment	Delivery to rolling mill	Conversion cost	Delivery	Purchased from rolling mill	Purchased through distributor
				Dollars per pound			
26	0.0919	0.0215	0.0021	0.0436	0.0036	0.1627	0.2034
20	.0935	.0155	.0021	.0385	.0036	.1532	0.1915

speeds up installation. Likewise, precutting of parts by the steel supplier tends to result in faster installation time. Although steel stud installation can vary from 75 to 125 percent of the time required to install wood studs, the lower amount was used in this study to reflect what is typical of the large volume builders that might use steel studs. Table 26 shows labor requirements for installing steel studs.

Labor wages.-- The wages used in calculating steel framing costs are the same as for wood framing. Currently, studs are installed by carpenters or drywall installers. See table 20 for wage rates. Half the labor is assumed to be by carpenter and half by laborer.

Table 26.--Labor requirements per linear foot for erecting wall frames of steel 1/

Nonload-bearing partitions

Nominal stud size	Stud spacing in inches	Simple framing with well-planned usage	Typical house	Complex framing without well-planned usage
		Man-minutes	Man-minutes	Man-minutes
2x2, 2x3, 2x4	16	2.23	3.10	3.97
2x2, 2x3, 2x4	24	2.00	2.67	3.33

Load-bearing walls

All	16	3.41	4.73	6.05
configurations	24	3.23	4.49	5.60

1/ Including door and window openings except door openings that are full ceiling height.

Total in-place cost--Tables 27, 28, and 29 present estimated in-place costs of steel wall framing in each of the three selected cities. Two levels of distribution were considered:

- Large volume builders that purchase directly from the rolling mill.
- Builders, regardless of quantity bought, purchasing from steel distribution centers.

Large volume builders with low labor costs who purchase direct from the rolling mill have advantages over builders with high labor costs who purchase from a steel distribution center.

The fastener cost for wood partition framing is about $0.02 per linear foot and for steel partition framing is slightly over $0.01 per linear foot. For drywall application, fastener cost for wood partitions is about $0.01 and for steel $0.04 per linear foot. Total in-place fastener cost for wood then is $0.03 and for steel $0.05 per linear foot. The differential fastener cost between wood and steel is a very small percentage of the total in-place cost. For this reason fastener cost was not included in the interior partition or exterior wall in-place cost totals. Adhesives are very popular for installing drywall or wood paneling which would tend to nulify the difference in cost between fasteners for wood and those for steel systems.

Some gypsum wallboard manufacturers recommend use of screws for both wood framing and steel framing; this also tends to nulify the cost difference.

Figure 4 illustrates comparative costs for wood and steel framing in nonload-bearing partitions and load-bearing exterior walls. In brief, the picture is this:

- 26-gage 2x3 interior partition metal studs on a per piece basis cost a bit more than lumber in 1970, but cost less to install than 2x3 wood studs. In a high labor cost area such as Chicago, savings could amount to as much as $0.20 per linear foot of wall. In a low labor cost area such as Washington, D. C., the savings might be $0.05 per linear foot.

- 26-gage 2x3 interior partition metal studs do not meet FHA requirements, but if heavier gage studs are used there is still a cost advantage over wood. If labor wages continue to rise more rapidly than materials prices, the cost advantage of "snap-in" steel construction will become greater.

Table 27.--In-place costs of steel framing per linear foot of nonload-bearing partitions and exterior load-bearing walls[1] in the Chicago metropolitan area during 1970

Type builder and wall framing			Materials			Labor			Total in-place cost per linear foot
Type builder	Nominal stud size	Stud spacing in inches	Per linear foot	Price per pound	Cost per linear foot	Per linear foot	Wage per man-minute	Cost per linear foot	
			Pounds	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars
	Partitions								
Large volume builder purchasing directly from rolling mill	2x2	16	3.02	0.1627	0.4914	3.10	0.1246	0.3863	0.8777
	2x3	16	3.75	.1627	.6101	3.10	.1246	.3863	.9964
	2x4	16	4.52	.1627	.7354	3.10	.1246	.3863	1.1217
	2x2	24	2.76	.1627	.4491	2.67	.1246	.3327	.7818
	2x3	24	3.30	.1627	.5369	2.67	.1246	.3327	.8696
	2x4	24	3.99	.1627	.6492	2.67	.1246	.3327	.9819
	Exterior walls								
	All configurations	16	8.50	.1532	1.3022	4.73	.1246	.5894	1.8916
		24	8.50	.1532	1.3022	4.49	.1246	.5595	1.8617
	Partitions								
Builders purchasing from a steel distribution center	2x2	16	3.02	.2034	.6143	3.10	.1246	.3863	1.0006
	2x3	16	3.75	.2034	.7628	3.10	.1246	.3863	1.1491
	2x4	16	4.52	.2034	.9194	3.10	.1246	.3863	1.3057
	2x2	24	2.76	.2034	.5614	2.67	.1246	.3327	.8941
	2x3	24	3.30	.2034	.6712	2.67	.1246	.3327	1.0039
	2x4	24	3.99	.2034	.8116	2.67	.1246	.3327	1.1443
	Exterior walls								
	All configurations	16	8.50	.1915	1.6278	4.73	.1246	.5894	2.2172
		24	8.50	.1915	1.6278	4.49	.1246	.5595	2.1873

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[1] Including door and window openings except door openings extending to the ceiling.

Table 28.--In-place costs of steel framing per linear foot of nonload-bearing partitions and exterior load-bearing walls[1] in the Los Angeles metropolitan area during 1970

Type builder and wall framing			Materials			Labor			Total in-place cost per linear foot
Type builder	Nominal stud size	Stud spacing in inches	Per linear foot	Price per pound	Cost per linear foot	Per linear foot	Wage per man-minute	Cost per linear foot	
			Pounds	Dollars	Dollars	Man-Minutes	Dollars	Dollars	Dollars
	Partitions								
Large volume builder purchasing directly from rolling mill	2x2	16	3.02	0.1627	0.4914	3.10	0.1167	0.3618	0.8532
	2x3	16	3.75	.1627	.6101	3.10	.1167	.3618	.9719
	2x4	16	4.52	.1627	.7354	3.10	.1167	.3618	.0972
	2x2	24	2.76	.1627	.4491	2.67	.1167	.3116	.7607
	2x3	24	3.30	.1627	.5369	2.67	.1167	.3116	.8485
	2x4	24	3.99	.1627	.6492	2.67	.1167	.3116	.9608
	Exterior walls								
	All configurations	16	8.50	.1532	1.3022	4.73	.1167	.5520	1.8542
		24	8.50	.1532	1.3022	4.49	.1167	.5240	1.8262
	Partitions								
Builders purchasing from a steel distribution center	2x2	16	3.02	.2034	.6143	3.10	.1167	.3618	0.9761
	2x3	16	3.75	.2034	.7628	3.10	.1167	.3618	1.1246
	2x4	16	4.52	.2034	.9194	3.10	.1167	.3618	1.2812
	2x2	24	2.76	.2034	.5614	2.67	.1167	.3116	.8730
	2x3	24	3.30	.2034	.6712	2.67	.1167	.3116	.9828
	2x4	24	3.99	.2034	.8116	2.67	.1167	.3116	1.1232
	Exterior walls								
	All configurations	16	8.50	.1915	1.6278	4.73	.1167	.5520	2.1798
		24	8.50	.1915	1.6278	4.49	.1167	.5240	2.1518

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[1] Including door and window openings except door openings extending to the ceiling.

Table 29.--In-place costs of steel framing per linear foot of nonload-bearing partitions and exterior load-bearing walls[1] in the Washington, D.C., metropolitan area during 1970

Type builder and wall framing			Materials			Labor			Total in-place cost per linear foot
Type builder	Nominal stud size	Stud spacing in inches	Per linear foot	Price per pound	Cost per linear foot	Per linear foot	Wage per man-minute	Cost per linear foot	
			Pounds	Dollars	Dollars	Man-minutes	Dollars	Dollars	Dollars
	Partitions								
Large volume builder purchasing directly from rolling mill	2x2	16	3.02	0.1627	0.4914	3.10	0.0634	0.1965	0.6869
	2x3	16	3.75	.1627	.6101	3.10	.0634	.1965	.8066
	2x4	16	4.52	.1627	.7354	3.10	.0634	.1965	.9319
	2x2	24	2.76	.1627	.4491	2.67	.0634	.1693	.6183
	2x3	24	3.30	.1627	.5369	2.67	.0634	.1693	.7062
	2x4	24	3.99	.1627	.6492	2.67	.0634	.1693	.8185
	Exterior walls								
	All configurations	16	8.50	.1532	1.3022	4.73	.0634	.2999	1.6021
		24	8.50	.1532	1.3022	4.49	.0634	.2847	1.5869
	Partitions								
Builders purchasing from a steel distribution center	2x2	16	3.02	.2034	.6143	3.10	.0634	.1965	.8108
	2x3	16	3.75	.2034	.7628	3.10	.0634	.1965	.9593
	2x4	16	4.52	.2034	.9194	3.10	.0634	.1965	.1159
	2x2	24	2.76	.2034	.5614	2.67	.0634	.1693	.7307
	2x3	24	3.30	.2034	.6712	2.67	.0634	.1693	.8405
	2x4	24	3.99	.2034	.8116	2.67	.0634	.1693	.9809
	Exterior walls								
	All configurations	16	8.50	.1915	1.6278	4.73	.0634	.2999	1.9277
		24	8.50	.1915	1.6278	4.49	.0634	.2847	1.9125

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[1] Including door and window openings except door openings extending to the ceiling.

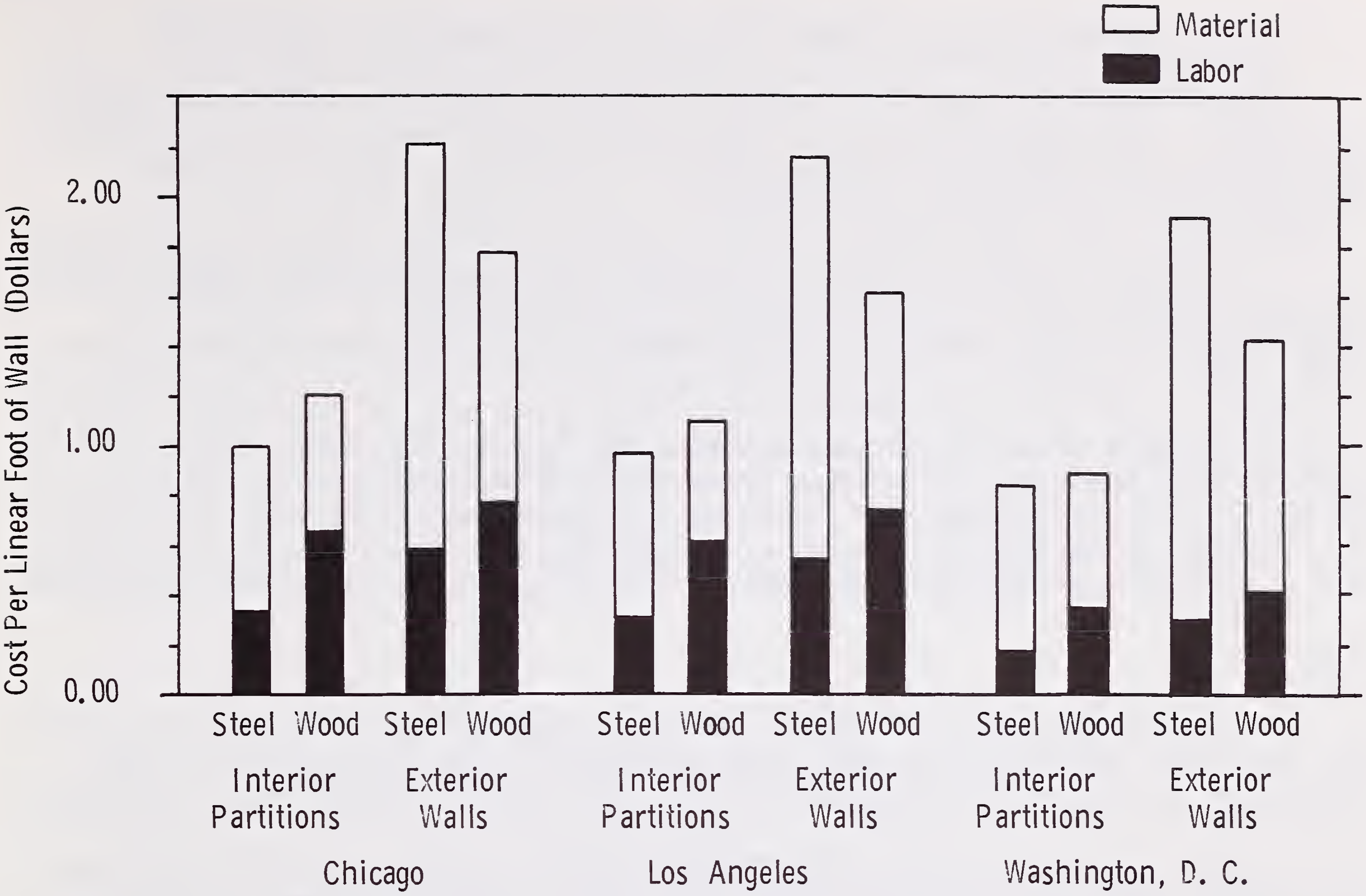

Figure 4.--Comparative in-place costs at 1970 prices for wood and steel interior partitions using 2x3 studs spaced 24 inches on center and exterior walls using 2x4 studs spaced 16 inches on center, purchased in large volume through local retail outlets.

- Wood studs in 1970 had a substantial cost advantage over steel studs for exterior load-bearing wall construction--$1.27 to $1.88 per linear foot compared to $1.59 to $2.22.

- By well-planned usage of material, costs of both wood and steel framing can be reduced below the levels presented.

- Disadvantages of steel framing for exterior walls include the relatively large quantity required to meet structural requirements. In nonload-bearing interior walls, where structural requirements are much lower, steel has the advantage of easy assembly and snap-in type construction that reduces labor costs.

COST OF WOOD VERSUS STEEL FLOOR AND WALL FRAMING AT 1972 PRICES

This analysis compares in-place costs of residential floor and wall framing at 1970 and 1972 prices. Wages and prices of materials for the Los Angeles area were used in this part of the study. These costs were between those in Chicago and Washington.

In 1972, prices of lumber and plywood were substantially higher than in 1970, whereas steel prices were only slightly greater. This had the effect of increasing in-place costs of wood relative to steel frame construction.

In-place costs of floors, exterior walls, and partitions were calculated using 1972 mid-October prices for steel, average 1972 wages for labor, and various prices for lumber including the 1972 mid-October prices. The results of these computations are shown graphically in figures 5 and 6 for floors, 7 and 8 for exterior walls, and 9 and 10 for interior partitions.

Floors

In 1970 the price of lumber for floor framing was about $141 per M bd. ft. for small and $124 for large volume builders. By mid-October of 1972 the price had risen to $230 per M bd. ft. and $202 for large volume builders.

The in-place cost for wood-framed floors in 1970 was about $0.14 less per square foot than for steel floors for small volume builders and $0.09 less for large volume builders. In the fall of 1972, in-place costs for small volume builders still favored wood frame construction but the difference shrank from $0.14 to $0.03 per square foot. For large volume builders, the difference shrank from $0.09 to $0.00 per square foot.

Exterior Walls

In 1970, the in-place cost of wood-framed exterior walls was about $0.45 less per linear foot than that of steel for small volume builders and $0.24 less per linear foot for large volume builders. Wood wall framing cost small volume builders $114 per M bd. ft. and large volume builders $100 per M bd. ft. in 1970. By mid-October 1972, lumber prices had risen to $205 per M bd. ft. for small and $181 for large volume builders. This shifted the cost in favor of steel by about $0.16 per linear foot for small and $0.32 per linear foot for large volume builders.

Interior Partitions

The cost of interior partition lumber in 1970 and 1972 was essentially the same as that of exterior wall framing discussed above. However, the 1970 in-place cost of interior partitions was in favor of steel by about $0.16 per linear foot for small and $0.23 for large volume builders. In 1972 in-place cost favorable to steel shifted to $0.58 per linear foot for small and $0.62 for large volume builders.

Few builders keep accurate cost records on a component-by-component basis. It is more typical to keep cost on a per house basis, especially for small builders. However, astute builders that keep unit records will begin to discover savings that result from use of steel framing.

If high lumber prices persist, it would be reasonable to expect shifts from lumber to steel framing to occur within the next few years since steel prices remain relatively stable.

In this part of the study quantities of material and labor required for framing were assumed to be essentially the same in 1972 as in 1970. A further assumption is that wood floors were framed with 2x8 joists spaced 16 inches on center and 18-gage 2x8 steel joists spaced 24 inches on center. Exterior walls were assumed to be constructed using 2x4 studs spaced 16 inches on center and 20-gage steel studs spaced 16 or 24 inches on center. Interior partitions were assumed to be constructed using 2x3 wood studs spaced 24 inches on center and 26-gage steel studs spaced 24 inches on center.

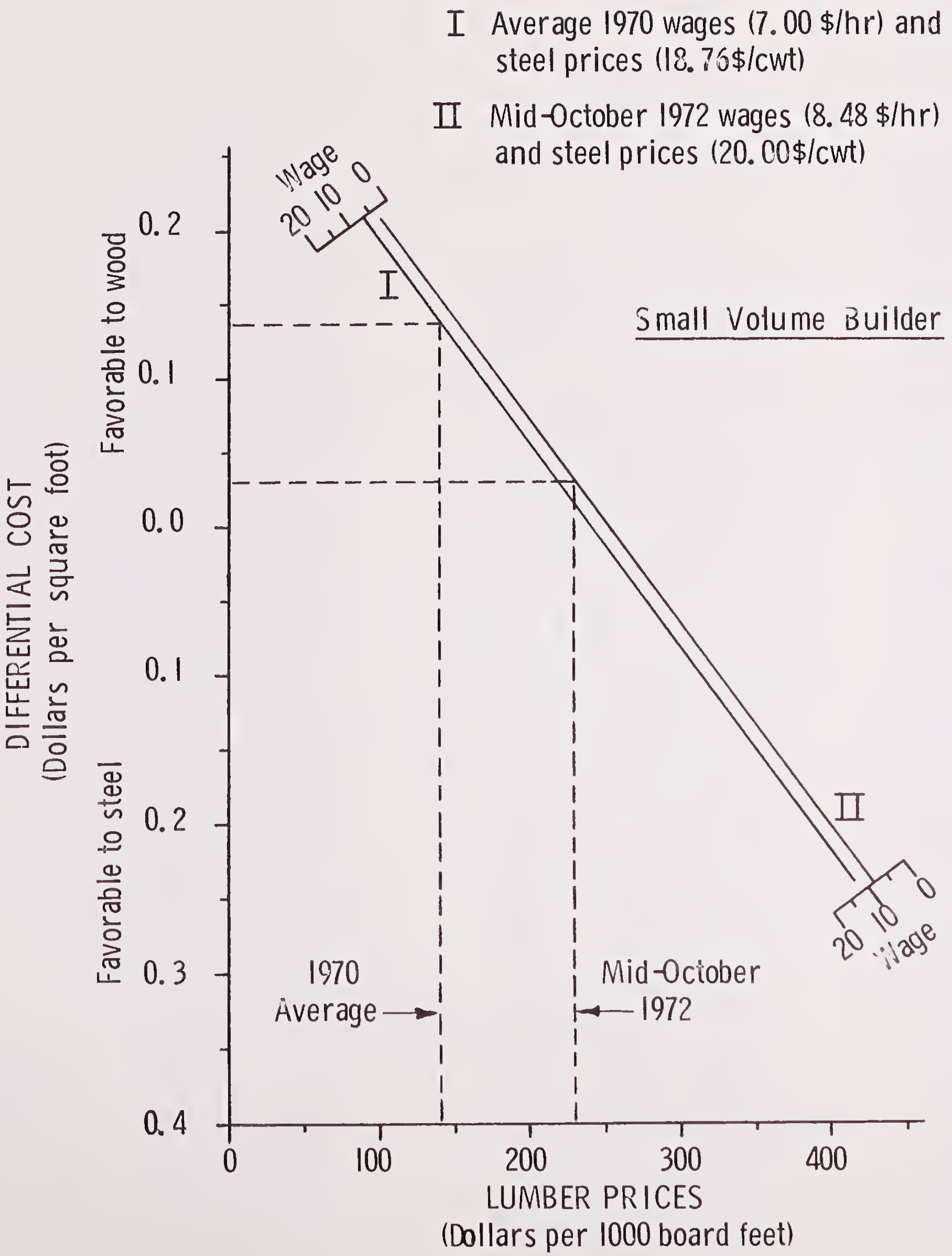

Figure 5.--Differential cost between floors framed with wood versus steel at 1970 and 1972 prices, small volume builders.

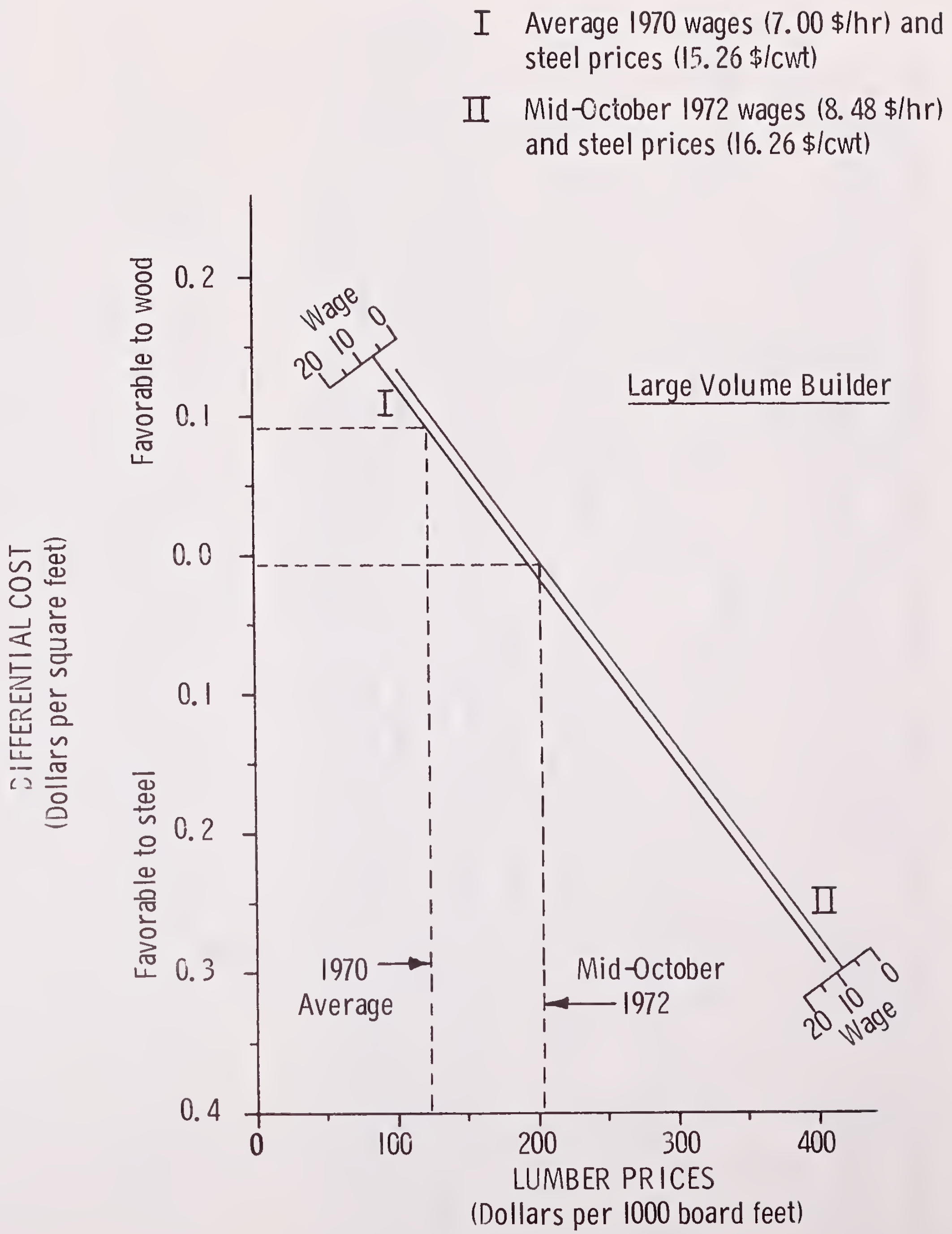

Figure 6.--Differential cost between floors framed with wood versus steel at 1970 and 1972 prices, large volume builders.

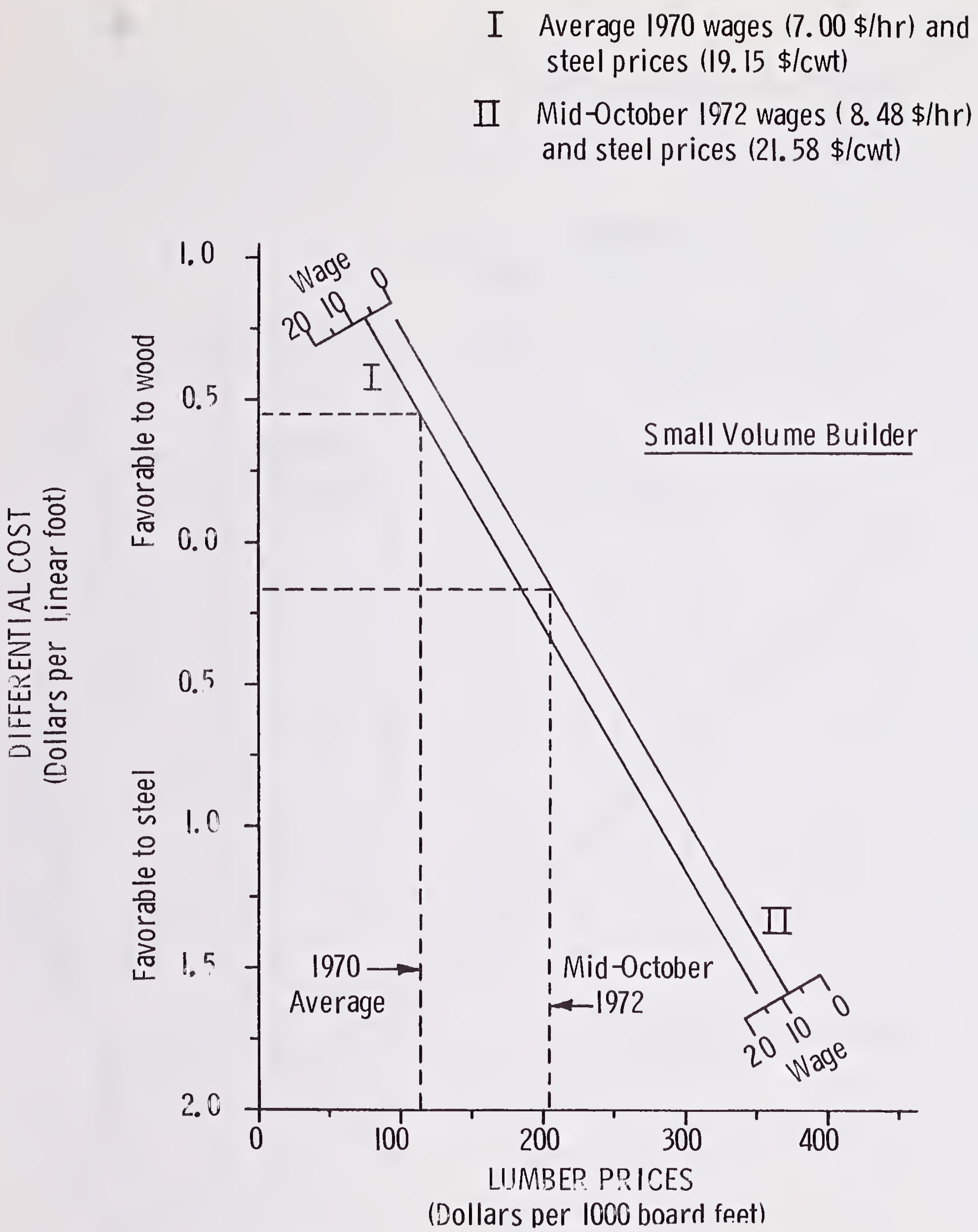

Figure 7.--Differential cost between exterior walls framed with wood versus steel at 1970 and 1972 prices, small volume builders.

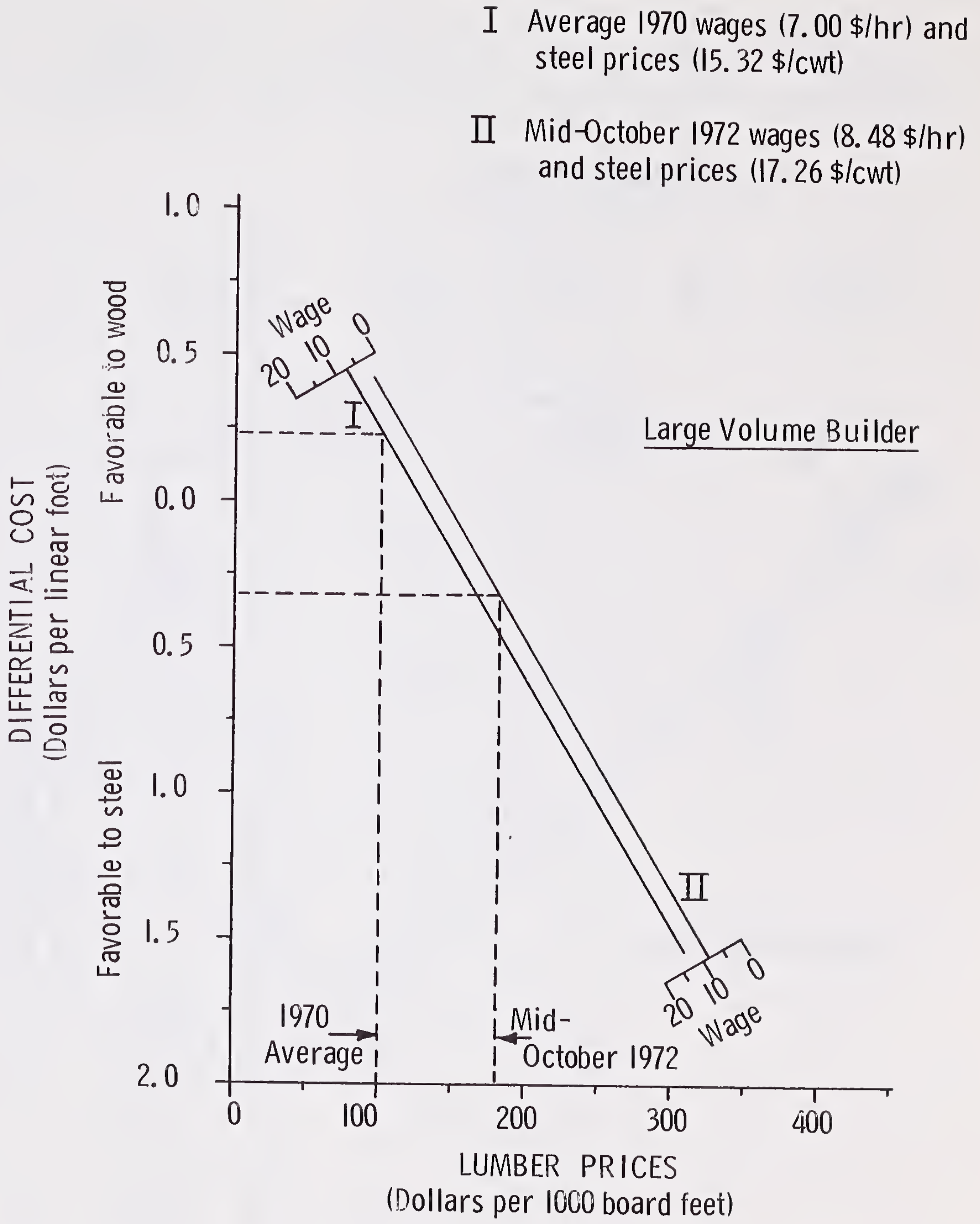

Figure 8.--Differential cost between exterior walls framed with wood versus steel at 1970 and 1972 prices, large volume builders.

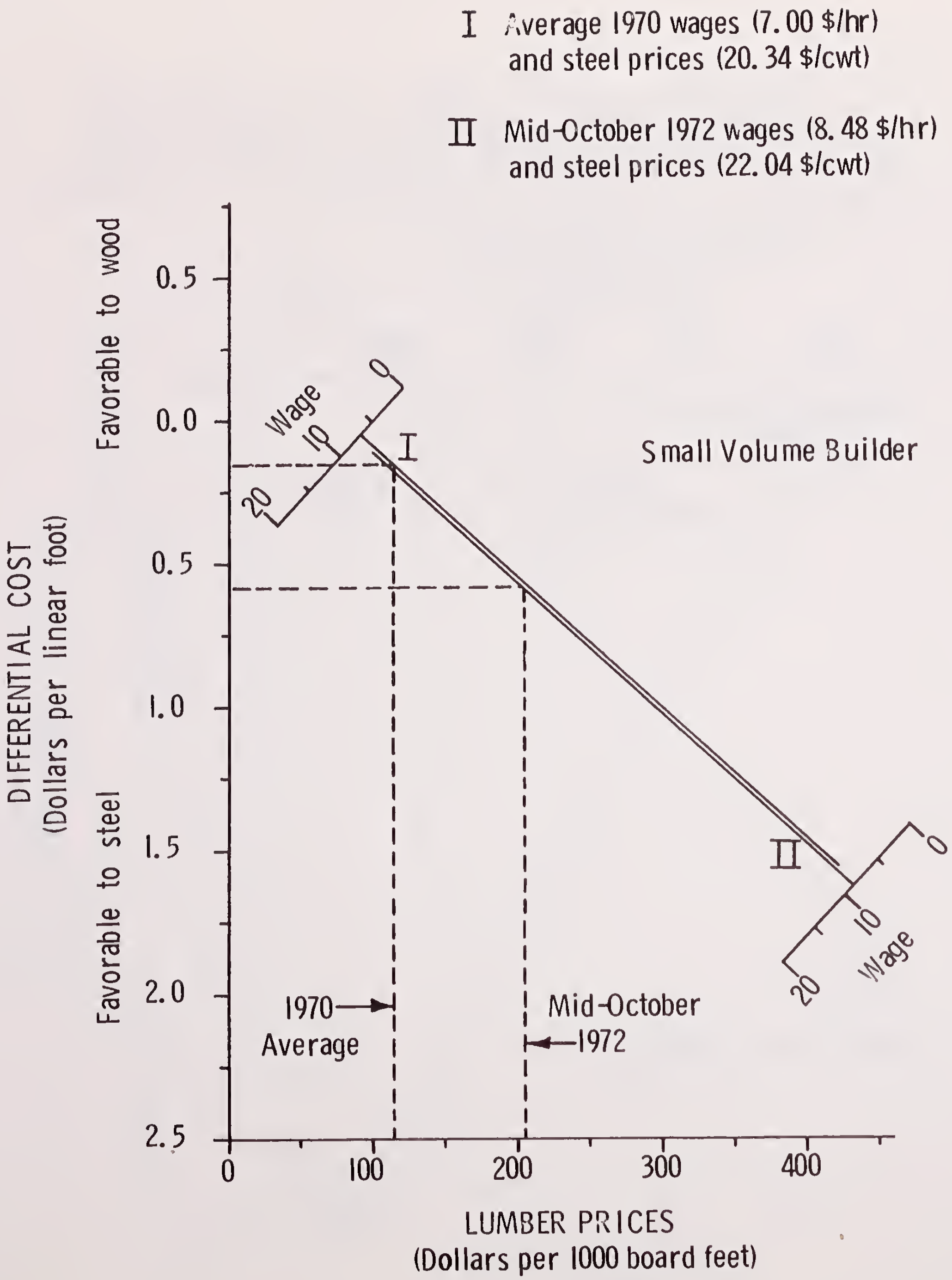

Figure 9.--Differential cost between interior partitions framed with wood versus steel at 1970 and 1972 prices, small volume builders

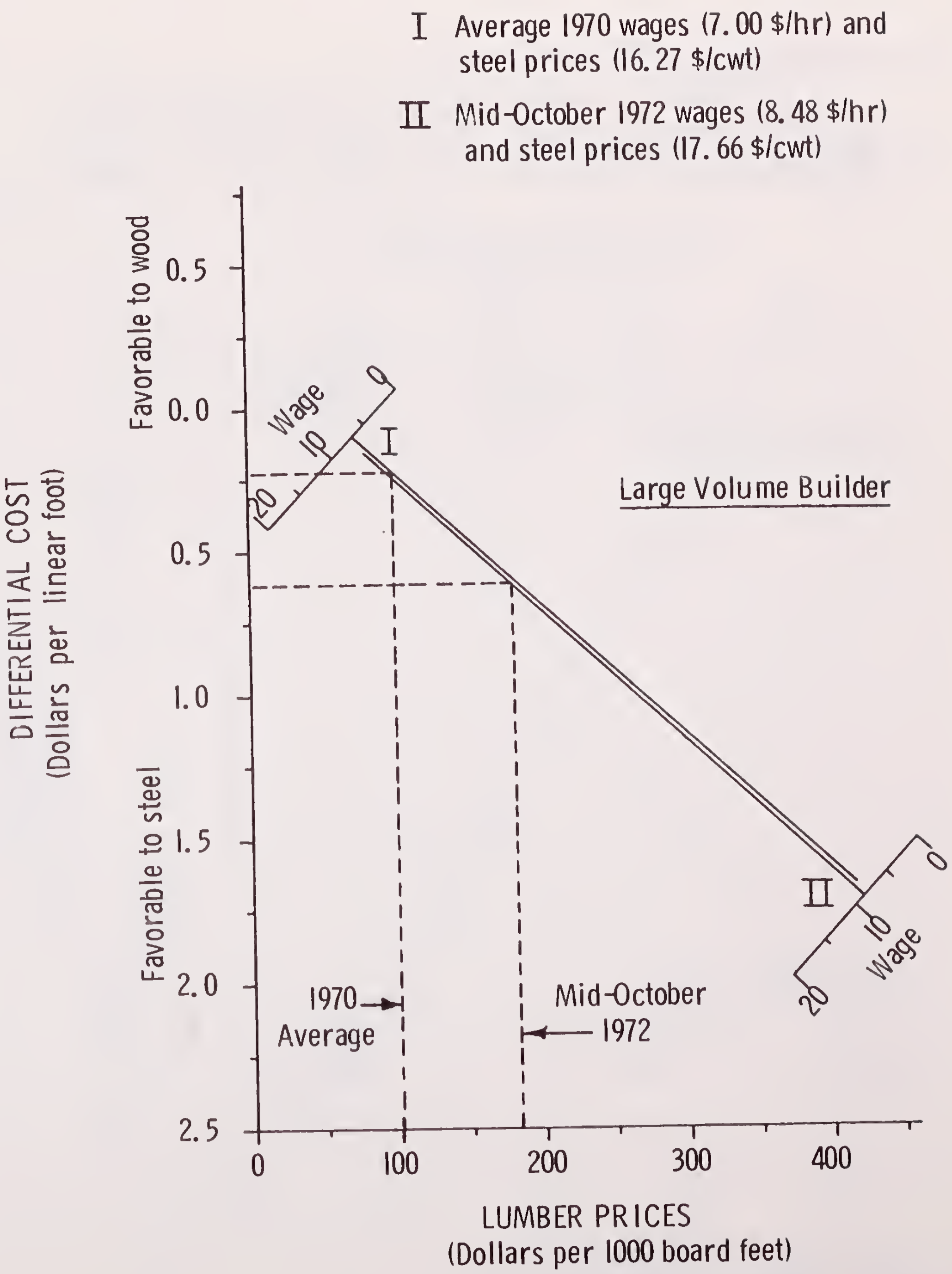

Figure 10.--Differential cost between interior partitions framed with wood versus steel at 1970 and 1972 prices, large volume builders.

APPENDIX

Prices Builders Pay for Lumber and Plywood

The prices builders pay for various species and grades of lumber and plywood used in this report were arrived at by adding shipping costs and sales distribution markups to f.o.b. mill prices. However, there can be considerable variation in shipping costs, markups, and f.o.b. mill prices. To arrive at a representative price that builders pay for lumber, the f.o.b. mill prices and the amounts added to the f.o.b. mill prices for sales markup and delivery costs must represent those that are typical in the market place.

F.o.b. mill prices--there are a large number of lumber and plywood manufacturing companies that make this industry a highly competitive business. Because of this highly competitive nature, f.o.b. mill prices can vary widely when there are changes in the supply and demand for lumber and plywood. If the supply is limited because of unavailability of railroad cars or marine cargo ships and weather constraints on logging operations, the f.o.b. mill price may rise sharply. Similarly, prices may rise because of an increase in demand for lumber created by changes in residential building activity (this is closely related to the availability of mortgage money and money for construction loans required to finance homebuilding), seasonal adjustments in retail lumber yard inventories, or retailers anticipation of price changes. To make costs comparisons between lumber and plywood, which have widely fluctuating prices, and steel, which has relatively stable prices, this study used a 12-month average f.o.b. lumber and plywood price during a period (1970) of relatively stable prices as a base to work from.

There were no readily available published f.o.b. mill prices for 1 1/8-inch thick plywood underlayment with two edges tongue and grooved that is used for single-layer floors. However, the f.o.b. mill price for this product was estimated with reasonable accuracy by using the f.o.b. mill price for 3/4-inch thick standard grade plywood with exterior glue as a base price. This base price was then increased by the amounts typically published for extra costs of grade C veneer cross-band, tongue and grooving on two edges, and the veneers required to provide the additional thickness.

Delivery costs--The amount of delivery costs added to the f.o.b. mill price depends upon the mode of transport, weight of species being shipped, and the distance from the point of origin to the point of consumption. In Chicago, lumber and plywood shipments for western woods are mostly by rail, but for southern pine, shipments may be by rail, truck, or barge. For western lumber, the rail rate changed several times during the year 1970, but the weighted rate was $1.58 per cwt for lumber and plywood shipped from the Northwest into Chicago. For southern pine lumber, about 48 percent of the rail and truck shipments were by truck and 52 percent by rail. Truck shipments were mostly from Alabama, Arkansas, Louisiana, and Mississippi, and rail shipments were mostly from Arkansas, Louisiana, Mississippi, and Texas. The weighted rate for truck shipments was $1.05 per cwt, and for rail shipments $0.83 per cwt from the States most frequently shipped from. The weighted freight rate for both rail and truck for southern pine was $0.938 per cwt. This is the amount used in this study for 1970 shipping rates into Chicago. Barge shipments were relatively small compared to truck and rail and were neglected in this study.

A similar analysis for Washington, D. C., resulted in typical shipping costs of $1.66 per cwt for western lumber and $0.51 per cwt for southern pine lumber. Plywood shipping rates are essentially the same as lumber rates except that a blanket freight rate on rail shipments into the Northeast typical for lumber does not apply to plywood which will have a slightly higher rate.

In Los Angeles, considerable lumber and plywood is shipped by rail and marine cargo and a small amount by truck. In this study, the rail rate was considered satisfactory to represent typical freight rates into Los Angeles for western woods. The 1970 rate used in this study was $0.77 per cwt. Southern pine lumber and plywood are not typically shipped into Los Angeles.

To arrive at the shipping costs for any city, typical freight rates discussed above are multiplied by the weight per thousand board feet for the species shipped. This shipping cost was added to the f.o.b. mill price to obtain a delivered cost at the point of destination.

Sales distribution markup--Lumber and plywood can pass through a wholesaler and then through a retail lumber yard. In large eastern metropolitan areas, it is most typical for large volume retail yards to purchase lumber and plywood directly from the producing mill and no wholesaler markup is involved. The markup by retailing yards or by large volume builders that purchase directly from mills producing lumber and plywood is about 10 percent above the delivery price. This is the case for Chicago and Washington, D. C. However, in Los Angeles the situation is reversed and most retail yards purchase lumber and plywood through wholesalers. In this instance, the wholesale markup is about 5 percent of delivered price. In small cities and towns, especially in rural areas, it is typical for retail yards to purchase from wholesalers that mark up lumber as much as 18 percent, but this does not apply to the cities in this study.

Once retailers have received lumber or plywood, two markups are typical in selling these products to builders. If the builder picks up truckload quantities of lumber directly from the rail car or marine dockside or from tractor trailer trucks before the retailer places the material in stock bins, the retail markup is around 14-16 percent. If the builder purchases lumber or plywood in small quantities from inventories that have been placed in stock bins and the retailer delivers the lumber and plywood to the builder's job site, then the markup is typically between 23 and 26 percent.

Some examples will illustrate the above concepts (exhibits A, B, and C; tables 30, 31, and 32).

Example 1. Given: The 12-month average price for Number 2 S-dry 2x8-14 Southern pine is $94.83 per thousand board feet.

Required: Compute the cost to a small volume builder in Chicago.

F.o.b. mill costs	$ 94.83
Delivery costs--$0.94 cwt x 23.0 cwt per 1,000 bd. ft.	21.57
Delivered costs	116.40
Markup to small builders (25%)	29.10
Price to small builders	$145.50

Example 2. Given: The 12-month average price for Number 2 and better S-dry 2x10-12 Hem-fir is $87.08 per thousand board feet.

Required: Compute the cost to a large volume builder in Los Angeles who purchases through a local retail yard.

F.o.b. mill costs	$ 87.08
Delivery costs--$0.77 cwt x 23 cwt per 1000 bd. ft.	17.71
Delivered costs	104.79
Markup by wholesaler (5%)	5.24
Retail costs	110.03
Markup to large builder (15%)	16.51
Price to large builder	$126.54

Example 3. Given: 12-month average price for Number 2 and better S-dry 2x8-12 Douglas-fir larch is $97.08.

Required: Compute the cost to a large volume builder in the Washington, D. C., area who purchases directly from a lumber or plywood mill in the Northwest.

F.o.b. mill costs	$ 97.08
Delivery costs--$1.66 per cwt x 22.5 cwt per thousand bd. ft.	37.35
Delivered costs	134.43
Markup to large builder (10%)	13.45
Price to large builder	$147.88

Method of Arriving at Lumber and Plywood Freight Rates

For a given area such as Chicago, the lumber or plywood transportaion cost depends on where the shipment is from, the method of shipment (truck, rail, marine cargo, or barge), the prevailing transportation tariff, and weight of material shipped. Since all of these factors can change from day to day, there is no set or fixed freight rate. This study used weighted averages based on very limited data to arrive at a typical freight rate for a given city and grade of lumber.

EXHIBIT A

BUILDER PRICE FOR LUMBER AND PLYWOOD COMPUTATION SHEET Date 12-10-71 Sheet 1 of 3

Lumber or plywood description 2x8-14 (size) Southern Pine (species) 1/ No2 S-Dry (grade) 2/

Metropolitan area shipped to Chicago Region shipped from most truck from Ala, Ark., La. & Texas / most rail from Ark., La., Miss. & Texas

Assumed method of transport 48 % truck 52 % rail ____ % cargo (Some barge-unkwn)

Freight rates 105 truck 83 rail ____ cargo 93.8 weighted Weight per M 2300 #

Method of distribution and corresponding markups 10% - 15% - 25% ☒ retail ____ ☐ wholesale

Date priced 1970	F.O.B. mill price 3/	Average F.O.B. price	Weighted freight rate	Delivered price 4/	Wholesale price 5/	Builder prices		
						Pick-up before stock-in 6/	Large volume	Small volume
1/16	92	94.83	21.57	116.40	—	128.04	133.86	145.50
2/13	93							
3/13	89							
4/17	92							
5/15	95							
6/12	93							
7/17	90							
8/14	95							
9/18	100							
10/16	100							
11/13	100							
12/18	99							

Total 1138

1/ Species names were taken from National Design Specifications For Stress Grade Lumber and Its Fastenings (NDS), by National Forest Products Association, Washington, D. C., September 1, 1970. The equivalent species name used in trade publications prior to September 1970 may have been slightly different.

2/ Grade designations were taken from NDS September 1971. The equivalent grade name used in trade publications prior to September 1970 may have been slightly different.

3/ F.O.B. mill prices were taken from Random Lengths weekly report on lumber and plywood prices and marketing published by Random Lengths Publishing Company, Eugene, Oregon.

4/ This is called truck delivered, in-car or dockside price depending upon the method of transport. Cost of unloading varies between 2.50 to 5.00 per M BM.

5/ Wholesalers markup of 5 percent is used for Los Angeles area only. In Chicago and Washington, D. C., the wholesaler is by-passed about 75 percent of the time. In small rural cities, a wholesale markup is applicable in most areas of the country and varies between 8 and 13 percent.

6/ Builder purchases full carload shipments.

EXHIBIT B

BUILDER PRICE FOR LUMBER AND PLYWOOD COMPUTATION SHEET Date 12-10-71 Sheet 2 of 3

Lumber or plywood description 2x10 - 12 (size) Hem-Fir (species) 1/ No. 2 & Btr S-Dry (grade) 2/

Metropolitan area shipped to Los Angeles Region shipped from North Coast Group (Portland)

Assumed method of transport – % truck 100 % rail – % cargo

Freight rates ~ truck 77 rail – cargo 77 weighted Weight per M 2300#

Method of distribution and corresponding markups 10%-15%-25% ☒ retail 5% ☒ wholesale

Date priced 1970	F.O.B. mill price 3/	Average F.O.B. price	Weighted freight rate	Delivered price 4/	Wholesale price 5/	Builder prices Pick-up before stock-in 6/	Builder prices Large volume	Builder prices Small volume
1/16	83	87.08	17.71	104.79	110.03	121.04	126.54	137.54
2/13	83							
3/13	85							
4/17	85							
5/15	85							
6/12	85							
7/17	85							
8/14	90							
9/18	91							
10/16	91							
11/13	91							
12/18	91							

Total 1045

1/ Species names were taken from National Design Specifications For Stress Grade Lumber and Its Fastenings (NDS), by National Forest Products Association, Washington, D. C., September 1, 1970. The equivalent species name used in trade publications prior to September 1970 may have been slightly different.

2/ Grade designations were taken from NDS September 1971. The equivalent grade name used in trade publications prior to September 1970 may have been slightly different.

3/ F.O.B. mill prices were taken from Random Lengths weekly report on lumber and plywood prices and marketing published by Random Lengths Publishing Company, Eugene, Oregon.

4/ This is called truck delivered, in-car or dockside price depending upon the method of transport. Cost of unloading varies between 2.50 to 5.00 per M BM.

5/ Wholesalers markup of 5 percent is used for Los Angeles area only. In Chicago and Washington, D. C., the wholesaler is by-passed about 75 percent of the time. In small rural cities, a wholesale markup is applicable in most areas of the country and varies between 8 and 13 percent.

6/ Builder purchases full carload shipments.

EXHIBIT C

BUILDER PRICE FOR LUMBER AND PLYWOOD COMPUTATION SHEET

Date 12-10-71 Sheet 3 of 3

Lumber or plywood description 2x8-12 (size) Douglas-fir-Larch (species) 1/ No2. &Btr S-Dry (grade) 2/

Metropolitan area shipped to Washington, D.C. Region shipped from North Coast Group

Assumed method of transport - % truck 100 % rail - % cargo

Freight rates - truck 166 rail - cargo 166 weighted Weight per M 2250#

Method of distribution and corresponding markups 10%-15%-25% ☒ retail ☐ wholesale

Date priced 1970	F.O.B. mill price 3/	Average F.O.B. price	Weighted freight rate	Delivered price 4/	Wholesale price 5/	Builder prices: Pick-up before stock-in 6/	Builder prices: Large volume	Builder prices: Small volume
1/16	94	97.08	37.35	134.43	-	147.88	154.60	168.04
2/13	92							
3/13	94							
4/17	98							
5/15	96							
6/12	93							
7/17	93							
8/14	98							
9/18	102							
10/16	102							
11/13	102							
12/18	101							
Total	1165							

1/ Species names were taken from National Design Specifications For Stress Grade Lumber and Its Fastenings (NDS), by National Forest Products Association, Washington, D. C., September 1, 1970. The equivalent species name used in trade publications prior to September 1970 may have been slightly different.

2/ Grade designations were taken from NDS September 1971. The equivalent grade name used in trade publications prior to September 1970 may have been slightly different.

3/ F.O.B. mill prices were taken from Random Lengths weekly report on lumber and plywood prices and marketing published by Random Lengths Publishing Company, Eugene, Oregon.

4/ This is called truck delivered, in-car or dockside price depending upon the method of transport. Cost of unloading varies between 2.50 to 5.00 per M BM.

5/ Wholesalers markup of 5 percent is used for Los Angeles area only. In Chicago and Washington, D. C., the wholesaler is by-passed about 75 percent of the time. In small rural cities, a wholesale markup is applicable in most areas of the country and varies between 8 and 13 percent.

6/ Builder purchases full carload shipments.

Table 30.--Summary of 1970 estimated lumber prices builders paid for 2x8 and 2x10 floor joists in the Chicago area[1]

Species and sizes	Grade	Large volume purchased direct from lumber mill	Large volume purchased from retail lumber yard	Small volume purchased from retail lumber yard
		-- Dollars per thousand board feet --		
Douglas-fir:				
2x8-12	No. 2 & better	147.09	153.77	167.16
2x8-14	do.	143.60	150.13	163.19
2x8-RL	Utility	80.73	84.40	91.74
2x10-12	No. 2 & better	159.41	166.66	181.15
2x10-14	do.	159.60	166.85	181.36
2x10-RL	Utility	80.96	84.64	92.00
Douglas-fir-larch:				
2x8-12	No. 2 & better	142.42	148.89	161.84
2x8-14	do.	138.02	144.29	156.84
2x8-RL	Utility	81.83	85.55	92.99
2x10-12	No. 2 & better	157.40	164.55	178.86
2x10-14	do.	157.67	164.84	179.18
2x10-RL	Utility	84.71	88.56	96.26
Hem-fir:				
2x8-12	No. 2 & better	130.78	136.72	148.61
2x8-14	do.	127.11	132.89	144.45
2x8-RL	Utility	76.97	80.47	87.47
2x10-12	No. 2 & better	135.77	141.94	154.28
2x10-14	do.	141.27	147.69	160.53
2x10-RL	Utility	77.47	80.99	88.04
Southern pine:				
2x8-12	No. 2 & better	138.58	144.88	157.48
2x8-RL	No. 3	88.63	92.65	100.71
2x10-12	No. 2 & better	136.69	142.90	155.33
2x10-14	do.	139.99	146.35	159.08
2x10-RL	No. 3	96.90	101.31	110.12

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[1] All lumber assumed to be S-dry grade and species grade name equivalent to current in-use name.

Table 31.--Summary of 1970 estimated lumber prices builders paid for 2x8 and 2x10 floor joists in the Los Angeles area 1/

Species and sizes	Grade	Large volume purchased direct from lumber mill	Large volume purchased from retail lumber yard	Small volume purchased from retail lumber yard
		-- Dollars per thousand board feet --		
Douglas-fir:				
2x8-12	No. 2 & better	133.39	139.46	151.59
2x8-14	do.	129.74	135.64	147.44
2x8-RL	Utility	65.59	68.57	74.54
2x10-12	No. 2 & better	145.86	152.49	165.75
2x10-14	do.	146.06	152.70	165.98
2x10-RL	Utility	65.36	68.33	74.27
Douglas-fir-larch:				
2x8-12	No. 2 & better	132.15	138.15	150.17
2x8-14	do.	127.53	133.32	144.92
2x8-RL	Utility	66.75	69.78	75.85
2x10-12	No. 2 & better	143.75	150.29	163.35
2x10-14	do.	144.04	150.59	163.68
2x10-RL	Utility	67.43	70.50	76.63
Hem-fir:				
2x8-12	No. 2 & better	119.92	125.37	136.28
2x8-14	do.	116.07	121.35	131.90
2x8-RL	Utility	61.65	64.45	70.05
2x10-12	No. 2 & better	121.04	126.54	137.54
2x10-14	do.	126.81	132.58	144.10
2x10-RL	Utility	61.70	64.50	70.11

1/ All lumber assumed to be S-dry grade and species grade name equivalent to current in-use name.

Table 32.--Summary of 1970 estimated lumber prices builders paid for 2x8 and 2x10 floor joists in the Washington, D.C., area[1]

Species and sizes	Grade	Large volume purchased direct from lumber mill	Large volume purchased from retail lumber yard	Small volume purchased from retail lumber yard
		-- Dollars per thousand board feet --		
Douglas-fir:				
2x8-12	No. 2 & better	149.07	155.84	169.40
2x8-14	do.	145.59	152.20	165.44
2x8-RL	Utility	82.53	86.28	93.79
2x10-12	No. 2 & better	161.44	168.78	183.45
2x10-14	do.	161.62	168.97	183.66
2x10-RL	Utility	82.80	86.57	94.10
Douglas-fir-larch:				
2x8-12	No. 2 & better	147.87	154.60	168.04
2x8-14	do.	143.48	150.00	163.04
2x8-RL	Utility	83.63	87.44	95.04
2x10-12	No. 2 & better	159.42	166.67	181.48
2x10-14	do.	159.70	166.96	181.48
2x10-RL	Utility	86.73	90.68	98.56
Hem-fir:				
2x8-12	No. 2 & better	136.24	142.43	154.81
2x8-14	do.	132.57	138.59	150.65
2x8-RL	Utility	78.77	82.35	89.52
2x10-12	No. 2 & better	137.79	144.05	156.58
2x10-14	do.	143.29	149.80	162.83
2x10-RL	Utility	79.32	82.93	90.14
Southern pine:				
2x8-12	No. 2 & better	127.86	133.67	145.30
2x8-14	do.	117.32	122.65	133.31
2x8-RL	No. 3	77.90	81.44	88.53
2x10-12	No. 2 & better	125.50	131.20	142.61
2x10-14	do.	128.80	134.65	146.36
2x10-RL	No. 3	85.72	89.61	97.40

[1] All lumber assumed to be S-dry grade and species grade name equivalent to current in-use name.

For Southern pine lumber, about 97 percent of the truck shipments into Washington, D. C., were from South Carolina, North Carolina, and Virginia. About 74 percent of the rail shipments into Washington, D. C., were from Alabama, Arkansas, Oklahoma, Mississippi, and North Carolina. These shipments of Southern pine were from 120 mills that are members of the Southern Forest Products Association. Table 33 shows truck and rail weighted freight rates for Southern pine lumber shipped into Washington, D. C., from the States of most likely point of origin.

Truck shipments accounted for 65.8 percent and rail shipments 34.2 percent of all shipments reported in the Southern Forest Products Association data on shipments of Southern pine. A representative weighted freight rate for shipments into the Washington, D. C., area was calculated from data in table 33 as follows:

$$\text{Weighted rate} = (0.425)\ (0.658) + (0.685)\ (0.342) = \$0.514 \text{ per cwt}$$

A similar analysis for Chicago indicated a weighted freight rate is $0.938 per cwt. This rate was not weighted for lumber shipped by barge. Lumber rates by barge are less than by rail or truck, but little data were available on quantity being shipped by barge. The above rate may be slightly high because barge rates were not accounted for.

Table 33.--Weighted freight rates for Southern pine lumber shipped into Washington, D. C.

Shipping method	Quantity shipped in 6 months 1/	Proportion of total	State shipped from	Typical rate 2/ per cwt	Weighted rate
	Board feet	Percent		Dollars	Dollars
Truck	19,037,000	50.7	North Carolina	0.41	0.208
	4,959,000	12.9	South Carolina	.67	.086
	13,695,000	36.4	Virginia	.36	.131
	37,591,000	100.0			.425
Rail	2,497,000	16.8	Alabama	.65	0.109
	2,752,000	18.5	Arkansas-Oklahoma	1.15	.213
	6,044,000	40.7	Mississippi	.72	.293
	3,558,000	24.0	North Carolina	.29	.070
	14,851,000	100.0			.685

1/ Southern Forest Products Association, Statistical Department.
2/ Typical rates were supplied by traffic consultants.

For West Coast species, most shipments into Chicago, Los Angeles, and Washington, D. C., are from the coastal region of Oregon and Washington. Although considerable quantities of lumber come from the Rocky Mountain area, all lumber was assumed to come from a region identified as the North Coast Group by the Western Wood Products Association (WWPA), Portland, Oregon. Another assumption is that all shipments are by rail. Actually, there are shipments by marine cargo into Los Angeles and Washington, D. C. West Coast hemlock and white fir are species shipped by water from Canada into the Washington, D. C., area at rates between $3 and $6 less per thousand than by rail. For purpose of this study, it was not deemed necessary to make a rigorous analysis of the distribution of shipments of western lumber by rail and water mehods of shipments or by area shipped from.

Rail freight rates changed three times during 1970. Using three sets of freight rates for 1970 that were published by WWPA, a weighted average for lumber shipped from the North Coast Group into Chicago, Los Angeles, and Washington, D. C., was computed as shown in table 34.

Table 34.--Adjustment in freight rates to account for rate changes during the year 1970

City	Time rate was in effect	Rail rate per cwt Western Wood Products Association	Weighted rate
	Months	Dollars	
Chicago	6.0	1.53	0.765
	4.5	1.61	.604
	1.5	1.72	.215
			1.584
Los Angeles	6.0	.74	.370
	4.5	.78	.292
	1.5	.83	.104
			.766
Washington, D. C.	6.0	1.60	.800
	4.5	1.68	.630
	1.5	1.80	.225
			1.655

A summary of the weighted freight rate in dollars per cwt used in this study follows:

City	Southern species	Western species
Chicago	0.938	1.58
Los Angeles		.77
Washington, D. C.	.514	1.66

Plywood freight rates are essentially the same as lumber rates except in the Northeast where a blanket rate applies to lumber but not to plywood.

Prices Builders Pay for Steel Framing

Steel producting mills are located in all large metropolitan areas where most houses are built. Therefore, it is assumed that cost of steel varies little between geographic regions. Published prices that are typical for various cities throughout the United States tend to bear this out.

The price of steel depends on the type of galvanized coating. Light-gage steel framing must be galvanized according to most building codes in order to provide durability. Several types of galvanized coatings are possible, but the most common types are hot-dipped galvanizing and electrogalvanizing. Hot-dipped galvanizing is used for main structural members such as floor joists and load-bearing studs. Electrogalvanizing is used for secondary framing members such as nonload-bearing (partition) studs.

These steps were used in arriving at builder price.

1. An appropriate average base price for the type coating specified was determined from published price lists of various steel manufacturing firms. Adjustments were made in the base price for various thicknesses, widths, and for coil versus flat sheets. For example, in 1970 a typical base price was $9.35 per 100 pounds for hot-dipped galvanized flat coils. Price adjustments for thickness and width of floor joists rolled from coil stock 12 to 18 inches wide were:

Plus $0.60 to base price for 14 gage
Plus $1.00 to base price for 16 gage
Plus $1.30 to base price for 18 gage

2. Costs of delivery to rolling mill were added to the base price. In 1971, delivery costs varied upward from $0.0007 a pound for rolling mills adjacent to steel-making facilities to $0.0075 a pound for rolling mills 350 miles from the steel mill. In this study, it was assumed that in 1970 typical delivery by truck cost about $0.0021 a pound.

3. Costs of converting coil stock into a rolled structural shape were estimated from known selling prices of steel structural products. Figure 11 provides an estimated cost in dollars per pound to roll light-gage steel into structural shapes. The estimated cost of rolling into structural shapes was found by taking the difference between the delivered adjusted

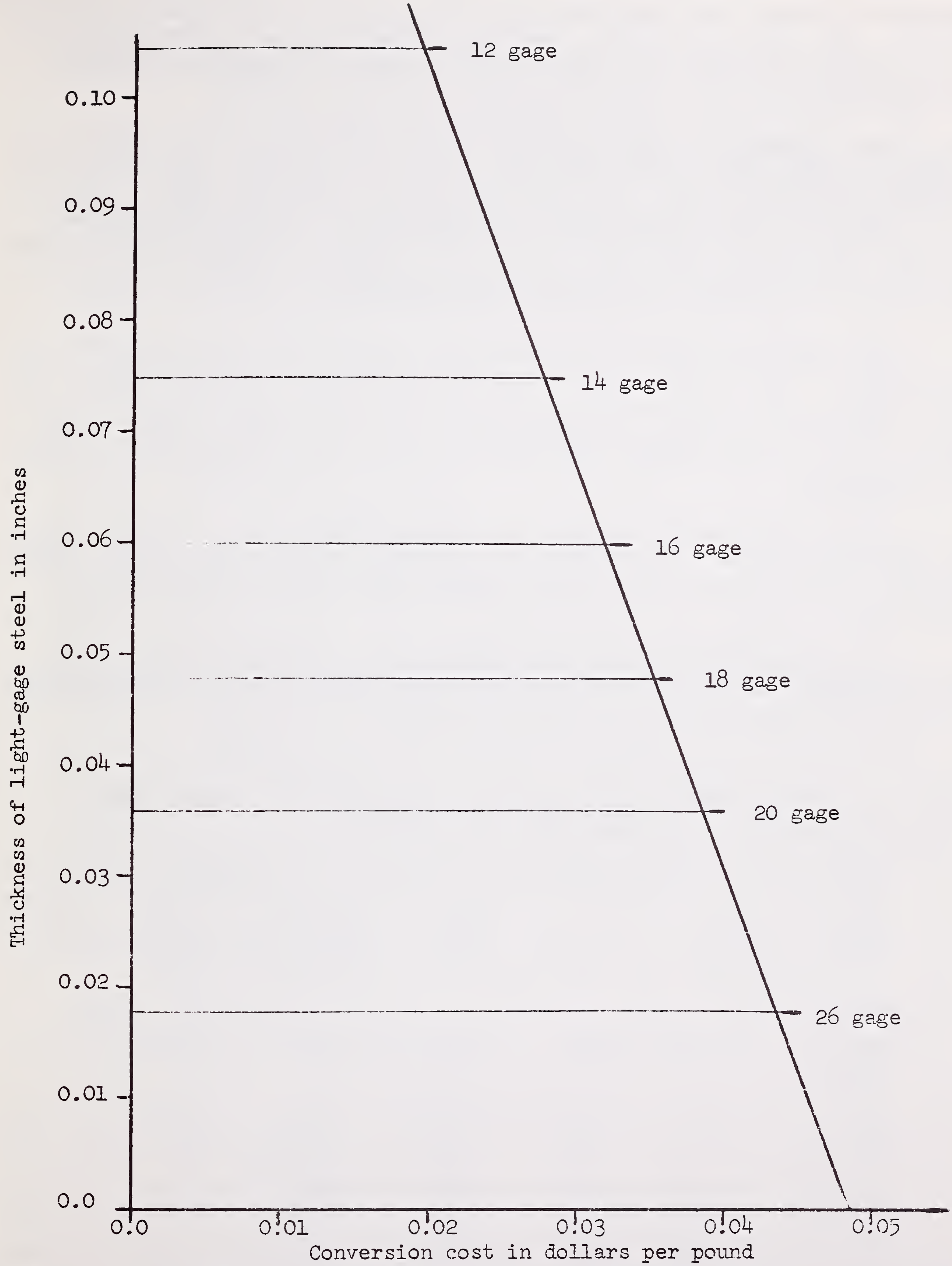

Figure 11.--Estimated value added to light-gage steel in conversion from flat coil stock to structural shape.

base price of steel and the delivered price paid by the distributor for the product. The delivery cost was based on a 50-mile distance from steel mill to the rolling mill and a 100-mile distance from the rolling mill to the distributor.

The average conversion cost determined in this manner for various gages was plotted on graph paper, and a straight line that reasonably represented the averaged values was drawn. The cost of rolling is probably more a function of the length of the product than its weight so the actual cost per pound can vary considerably from that shown on the graph. Conversion cost in this analysis means value added (labor, material, overhead, selling expense) in the process of producing light-gage steel products.

4. Determined cost of delivering the structural steel shapes to the distributor. This study assumed the average shipment to be 100 miles at the typical rates given in the second step for arriving at builder prices. The sum of the values in steps 1 through 4 is the price a large volume builder might pay for a steel product purchased directly from rolling mill in truckload quantities.

5. The distributor markup must then be determined. For this study the markup is assumed to be 25 percent for large volume sales (40,000 pounds minimum). Small volume sales (5,000 pounds) could have a markup of 50 or 60 percent.

Table 35 contains prices for various gages of steel and shows the amounts added to arrive at a builder price according to the above five steps.

Table 35.--1970 estimated cost in dollars per pound for various gages of light-gage steel members

Gage	Base price	Thickness adjustment	Delivery to rolling mill	Conversion cost	Delivery to distributor	Purchased from rolling mill	Purchased through distributor
26	0.0919 1/	0.0215	0.0021	0.0436	0.0036	0.1627	0.2034
20	.0935 2/	.0155	.0021	.0385	.0036	.1532	.1915
18	.0935 2/	.0130	.0021	.0353	.0036	.1475	.1844
16	.0935 2/	.0100	.0021	.0320	.0036	.1412	.1765
14	.0935 2/	.0060	.0021	.0277	.0036	.1329	.1661

1/ Electrogalvanized steel.
2/ Hot-dipped galvanized steel.

Two examples will illustrate the method of arriving at the values in table 35:

Example 1.--Determine the 1970 builder cost for a steel 2x3 26-gage interior partition stud purchased through a distributor. The stud weighs 0.398 pound per foot and is 8 feet long.

		Dollars per pound
Step 1	Base price of electrogalvanized steel	0.0919
	Adjustment for thickness	.0215
Step 2	Delivery to rolling mill	.0021
Step 3	Conversion cost	.0436
Step 4	Delivery to distributor	.0036
		0.1627
Step 5	Add 25 percent markup	.0407
	Builder cost	0.2034

8 x 0.398 x 0.2034 = $0.648 per stud

1,000 x 0.398 x 0.2034 = $80.95 per thousand linear feet.

Example 2.--Determine the 1970 builder cost for a steel 2x8 16-gage floor joist if purchased through a distributor and also if purchased directly from rolling mill. The joist weighs 2.4 pounds per foot and is 28 feet long.

		Dollars per pound
Step 1	Base price of hot-dipped galvanized steel	0.0935
	Adjustment for thickness	.0100
Step 2	Delivery to rolling mill	.0021
Step 3	Conversion cost	.0320
Step 4	Delivery to distributor	.0036
		0.1412
Step 5	Add 25 percent markup	.0353
	Builder cost	0.1765

Purchased from distributor--

28 x 2.4 x 0.1765 = $11.86 per joist

2.4 x 0.1765 = $ 0.424 per linear foot

Purchased direct from rolling mill--

28 x 2.4 x 0.1412 = $9.49 per joist

2.4 x 0.1412 = $0.339 per linear foot

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Koenigshof, Gerald A.

1974. Comparative in-place cost between wood and steel residential floor and wall framing. USDA Forest Serv. Res. Pap. WO-22, 56 p.

This study showed that at 1970 prices for materials and labor, in-place costs of wood-framed floors and exterior walls were substantially less than for steel framing; for interior partitions, slightly less. At the high prices for lumber and plywood in the fall of 1972, steel became competitive with wood framing for large volume builders. For small volume builders, however, in-place costs slightly favored wood. A shift from wood to steel for interior partitions can be expected if prices of lumber and plywood remain at 1972 levels and no new wood partition framing systems are developed to compete with steel.

Keywords: Residential building cost, homebuilding cost, steel house framing, floor framing cost, wall framing cost.

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